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The Partial Failure Through Undermining of the Zuni Dam, New Mexico.

The spillway, south abutment and extreme south end of the Zuni Dam, at Black Rock, N. Mex., were undermined on Sept. 6, 1909, by the passage of water underneath a cap of lava rock which flanked the dam and extended beneath the spillway. The spillway, or considerable portions of it, dropped 7 ft.; there was a settlement of 9 ft. at the junction of the spillway and the abutment of the dam; and a small portion of the earth fill at the south end of the dam was washed out, and there was a 5-ft. settlement some 30 ft. long in the earth-fill at the north end of the dam. The main body of the dam, which is a combination of rock-fill and hydraulic-earth-fill, appears to be uninjured. The undermining of the lava cap extended beneath a large area of the mesa, far beyond the dam and spillway (see Fig. 1).

We have secured an authoritative account of the accident, based on an official investigation, but that account will be better understood if we first give a general description of the dam. This we have compiled from the 1908 edition of J. D. Schuyler's "Reservoirs," where further particulars, including various illustrations, may be found.

The Zuni Dam is located 45 miles south of Gallup, N. Mex., near the western boundary of the state, on the Zuni Indian Reservation. It was built by the U. S. Indian Service to store water for irrigation. The work was done by means of Indian labor, with white foremen, under the general direction of Mr. W. H. Code, M. Am. Soc. C. E., Chief Engineer U. S. Indian Service, with the late J. B. Harper as engineer-in-charge, and with Mr. J. D. Schuyler, M. Am. Soc. C. E., of Los Angeles, Cal., as consulting engineer. The date of completion is not given, but presumably it was in the latter part of 1907.

The maximum height of the dam is 70 ft. Its cross-sectional dimensions, as well as the disposition of the rock and the earth of which it is composed, are shown by Fig. 2, which we have reproduced from Mr. Schuyler's book already mentioned. The crest of the rock-fill portion of the dam was 5 ft. wide and 720 ft. long. The stones on the down-stream face were placed by steam-operated derricks and the steps shown are 18 ins. high. The rock-fill interior mass "was chinked carefully with small stones."

During the construction of the rock fill a 75-ft. gap was left midway in its length for the passage of flood flows. On April 24, 1905, after the rock-fill on either side of this gap had been carried to full height, a record-breaking flood occurred, estimated at 14,000 sec. ft. for four hours and at more than 9,000 sec. ft. for the 20 hours following. The rock-fill was not damaged, but the bed of the stream was lowered 10 ft. and was also so widened as to increase the required amount of rock 24% above the original estimate.

On closing the gap, and before beginning the earth-fill, some 5 to 10 ft. of earth were placed against the rock to prevent the passage of the semi-liquid earth-fill. On using fine sand, no leakage occurred, but

at the outset when moist clay was placed against the rock shrinkage cracks appeared which permitted leakage and loss before they would soak up and close.

We have cited the flood incident and the placing of the earth layer against the rock-fill as of interest in connection with both the stability and tightness of the dam. As bearing further upon the integrity of the structure we quote a paragraph on the character of the earth-fill and add to it a second paragraph, describing the geological formation at the site of the dam and telling why a regular type of masonry dam was not built:

Owing to the fact that all of the earth used was either very fine sand or clay, both equally impervious in an embankment placed and solidified by water, no attempt was made to separate the particles, or segregate the clay from the sand, as is customary in building hydraulic-fill dams, where the available materials are an admixture of gravel, rock, clay, and sand. Hence it was immaterial at what point against the rock-fill the material was discharged, so long as no horizontal stratifications appeared.

* * * * * *

The geological formation of this locality is quite peculiar. The Zuni River has here broken through a sheet of lava which at some remote period flowed from a volcano to the north of the valley and spread in a wide, horizontal blanket over the country, covering the alluvial soil to a depth of about 30 ft. Underneath the lava cap (the top of which is at the crest of the dam) are successive layers of sand and clay, while at a depth of 20 ft. below the river-bed dense blue clay is encountered, forming the impervious sub-floor of the reservoir. The erosion of the sand strata in the canyon and the breaking down of the lava cap by undermining had left the stream-bed filled with masses of hard basalt. This gave the impression of a canyon cut in rock from top to bottom, and was good ground for the presumption that a masonry dam would be best adapted to the site. Excavation, however, proved the unsuitability of the foundations for such a structure, and led to the final adoption of a type of dam which is flexible, and at the same time impervious to water. A spillway has been excavated in the solid rock on the south side of the dam, 100 ft. wide, 10 ft. deep.

The storage capacity of the reservoir formed by the Zuni Dam is 700,000,000 cu. ft.; its area, 623 acres; its drainage area, 650 sq. mi., extending to an elevation of 9,200 ft. on the Continental Divide.

GENERAL VIEW OF ZUNI ROCK-FILL AND HYDRAULIC-EARTH-FILL DAM, BLACK ROCK, N. M.
(One side of curved entrance to spillway in foreground.)

The following "brief statements of the flood damages as they were found at the Zuni Dam" were prepared and sent to this journal by Mr. W. H. Sanders, Consulting Engineer, Los Angeles, Cal., at the request of Mr. Wm. H. Code, M. Am. Soc. C. E., Chief Engineer of the Indian Service, who is also located at Los Angeles:

On the evening of Sept. 10, Engineer Hill, of the Indian Service and myself arrived at Black Rock to make examination and to report upon the damage to the dam.

We found the mesa south of dam had been undermined by the water, approximately 5,000 sec.-ft. passing under the same, causing a bad settlement of the mesa. This reached about 600 ft. south of the dam. The underflow destroyed the spillway, injured the south abutment of the dam and made a 9-ft. settlement at the point where the dam and spillway connect.

For about 600 ft. south from the dam the mesa has the appearance of a severe earthquake shock. Cracks and sink holes may be seen in all directions. The main body of the dam remains intact. On the morning of Sept. 5, a slight leakage was observed at the north end of the dam. It measured 124 gals. per min., water clear. On Sept. 6, it had increased to 467 gals. per min., water muddy. This was blanketed and stopped.

On the 6th water was found increasing rapidly in volume, issuing from the south side of the old channel of the river below the dam. This water changed from clear to muddy. However, no trace of leakage was observed along the toe of the dam. Later in the day, a settlement of the walls of the spillway was noticed and by 9 p. m. the whole spillway had dropped 7 ft. The outflow through the mesa at this period was estimated to be 5,000 sec.-ft. On the morning of the 7th the discharge was estimated to be only 1,800 sec.-ft. All of this water passed through the lava rock, except where the current had washed out a portion of the earth-fill in the south end of the dam. On the evening of the same date water was seen coming out from under the rock of the south mesa, about 600 ft. below the dam.

On the accompanying map of the mesa (Fig. 1) a large sink hole or break, marked with two crosses, is shown (see also the view, Fig. 8*). This break is in the top

[*Figs. 3 to 7, not mentioned in Mr. Sander's statement, are from a collection of photographs forwarded by Mr. Sanders, through the courtesy of Mr. Code. For the front-page view we are indebted to the U. S. Indian Service.—Ed.]

of south mesa and is where a very large body of water escaped at an early period of the trouble, carrying with it the top soil several feet in depth.

At the time of the arrival of Engineer Hill and myself, the water had receded to a lower level and was not escaping at this point but we could hear and trace the underflow from point marked "A" on Fig. 1 (line indicated by arrows) to small "a," thence changing due east to point "B" where it evidently divided, the larger part escaping at point marked "D," the remainder continuing to the east to point marked "C."

By looking at the view, Fig. 9, and at the left of point marked "C," in Fig. 1, it may be seen that a part of the high rock on the north side of the spillway is still in place. Before the flood, the rock formation, about 100 ft. wide, extended east to the dam. Now the whole mass, save this small portion, is ruptured and carried north toward the river bed, as shown in Fig. 10.

To the late Engineer Harper much credit should be given for the thorough and efficient work in the construction of this dam. That the design and construction of the dam was first class is self evident; the weak spot was the mesa.

Through the courtesy of the Indian Service, at Washington, D. C., we have secured copies of portions of two official reports on the accident, made by Mr. Sanders and by Mr. Rollin Ritter, Engineer-in-Charge of the dam. Mr. Ritter's report, dated Sept. 13, 1909, describes in some detail just what happened before and during the partial wreck of the structure. For the sake of making no break in his interesting story we print it in full, even though it repeats some of the information given above in Mr. Sander's letter to us:

On Sept. 5, the discharge below the dam was 124 gals. per min., water was clear and the gage in the reservoir showed 42.9 ft. of water.

It was noted on the morning of Sept. 6 that the gage indicated 45.6 ft. of water, while the weir below the dam showed a discharge of 467 gals. per min. Most of the water appeared to be coming around the north end of the dam. For the first time the water from the south side was muddy, having a brown color, the other leak being more of a red, muddy color. At noon the gage read 46.6 and the discharge below the dam was about the same.

Several times during the morning a close inspection was made of the south end of the dam and adjoining shore line of the reservoir but no trace of a leak could be seen.

The situation looked rather alarming, and no work on the ditch was attempted but the whole force was brought up to the dam in the early morning. The men were engaged in repair work on the north end until afternoon, when the water issuing from the south side of the old river channel below the dam was observed to increase in volume and change to a ruddy color.

A force was started filling sacks with dirt and carrying same to the top of the parapet wall on the south end of the dam. Attempts were made to locate the leak but no trace was observed along the toe of the dam or the shore. At four o'clock the leak increased to [illegible] cubic feet per second and soon afterwards a sm[illegible]lip was noticed in the earth-fill at the extreme south[illegible] of the dam. Five feet above the water line a [illegible]ll crack was visible. The riprap was torn up and a[illegible]s made to sluice dirt into the crack. After this [illegible] the discharge decreased considerably for several m[illegible]tes, then commenced again worse than ever. A wh[illegible]pool was seen about 12 ft. from the shore, sacks [illegible] were thrown in from a boat as fast as they could [illegible] handled and finally the whirlpool ceased. The re[illegible]ir then stood at the 47.1-ft. level, or lacking abo[illegible] 7 ft. of going over the spillway. At this time some [illegible]lement of the walls and north side of the spillway [illegible] noticed.

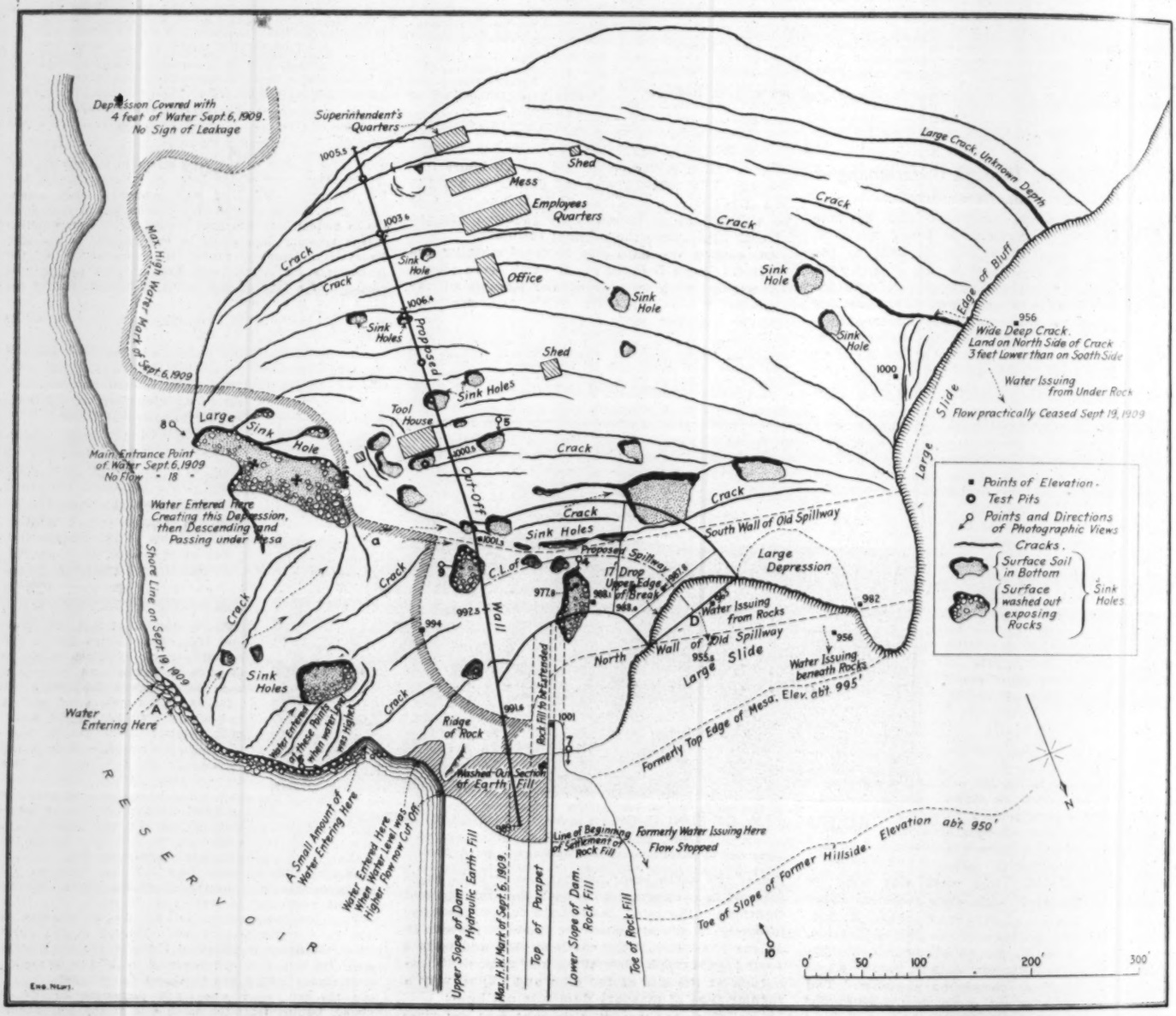

Depression Covered with 4 feet of Water Sept 6, 1909. No Sign of Leakage
Superintendent's Quarters
Shed
Mess
Employees Quarters
Office
Tool House
Large Crack, Unknown Depth
Crack
Sink Hole
Sink Holes
Edge of Bluff
Wide Deep Crack. Land on North Side of Crack 3 feet Lower than on South Side
Water Issuing from Under Rock
Flow practically Ceased Sept 19, 1909
Max. High Water Mark of Sept 6, 1909
Proposed
Cut-Off
Main Entrance Point of Water Sept 6, 1909 No Flow " 18 "
Water Entered Here Creating this Depression, then Descending and Passing under Mesa
Shore Line on Sept 19, 1909
Water Entering Here
Water Entered at these Points when Water Level was Higher
Ridge of Rock
Rock Fill to be Extended
Washed-Out Section of Earth Fill
A Small Amount of Water Entering Here
Water Entered Here when Water Level was Higher. Flow now Cut Off
Upper Slope of Dam. Hydraulic Earth-Fill
Max. H.W. Mark of Sept 6, 1909
Top of Parapet
Lower Slope of Dam. Rock Fill
Toe of Rock Fill
Line of Beginning of Settlement of Rock Fill
Formerly Water Issuing Here Flow Stopped
Toe of Slope of Former Hillside. Elevation abt 950'
Formerly Top Edge of Mesa. Elev. abt 995'
South Wall of Old Spillway
Proposed Spillway
17' Drop
Upper Edge of Break
C.L. of Wall
Large Depression
Water Issuing from Rocks
Wall of Old Spillway
North
Large Slide
Water Issuing beneath Rocks
Points of Elevation.
Test Pits
Points and Directions of Photographic Views
Cracks.
Surface Soil in Bottom
Surface washed out exposing Rocks
Sink Holes
RESERVOIR
0' 50' 100' 200' 300'

FIG. 1. MAP OF THE MESA SOUTH OF THE ZUNI DAM, BLACK ROCK, N. M., SHOWING HOW SPILLWAY AND END OF DAM WERE UNDERMINED.

(Map as on Sept. 20, 1909. The underflow that caused damage was first observed on Sept. 5 and settlement of the spillway and dam occurred on Sept. 6, 1909.)

The whirlpool opened two or three times more but seemed to be checked each time by the sacks used.

At the south end of the rock-fill, where the latter rested on the lava capping, a large volume of brown-colored water was seen spouting from under the lava and through the cracks in the same. An examination shortly before had shown the sand under the lava to be dry. By this time the spillway had settled several tenths, or enough so that water ran over the lip on the north side.

The whole spillway continued to settle and cracks open in the floor and in the rocks outside the lip. Attempts were made to fill the cracks with sacks of dirt and earth until the water drove the men back. Meantime warning had been given to the people of Zuni.

At 7 o'clock the north side of the spillway had settled two or three feet and water was running out the lower

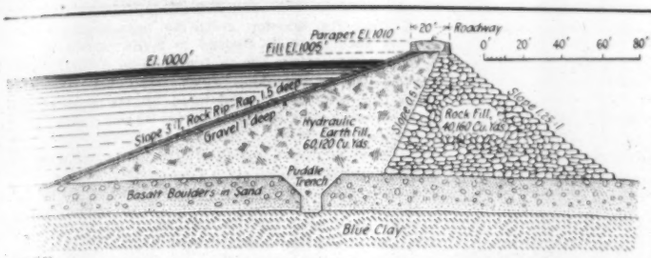


FIG. 2. CROSS-SECTION OF ZUNI DAM.
(Drawn from the second edition of Schuyler's "Reservoirs.")

end in considerable volume. By 9 o'clock the whole spillway had settled and part of the north wall fallen. The most of the water was discharging under the lava. The reservoir had fallen to 46.2. At 11 o'clock the water had lowered to 44.2. Allowing for the volume running in during this time the outflow must have been in the neighborhood of 5,000 cu. ft. per sec. At this time no water was running out the lower end of the spillway, but it was running back into the river channel through the breach in the north wall. The ground under all the camp buildings was cracked as if by an earthquake, considerable settlement all over had taken place and several sink-holes appeared.

At 5 a. m., Sept. 7, the gage in the reservoir read 42.5, about 900 acre-feet having escaped in the past six hours. The discharge averaged about 1,800 cu. ft. per sec.

The floor of the spillway was practically dry, all the water escaping through or under the lava rock except where the current had washed out a portion of the dirt-fill on the south end of the dam.

As this seemed the dangerous point, rock, sacks of earth and dirt were put in between the damaged end of the earth fill and the bluffs to cut down the stream washing around this end of the fill.

At 7 o'clock in the evening of Sept. 7 the lake had dropped 2.5 ft. more, the rate of discharge during the day averaging about 1,100 cu. ft. During the night the water worked through the bluff and in the morning was flowing under the rock at the point where the old quarry was located about 100 ft. south of the lower end of the spillway. Here a good-sized stream appeared where the day before there was no water except a small amount of seepage from a lower sand stratum and not the layer immediately under the lava. Much of the bluff had been undermined and had fallen to the hillside below.

On the morning of Sept. 8, the reservoir stood at the 38-ft. level and dropped 1 ft. more during the day. The flow during the night must have averaged about 1,000 cu. ft. per sec. and 500 cu. ft. per sec. during the day.

The cracks around the camp building became larger and new sink-holes appeared during the day. The flow around the earth-fill was checked but not entirely cut off by this time. From the evening of Sept. 8 to the same time of Sept. 9 the reservoir had dropped two feet more, the outflow averaging about 500 cu. ft. per sec. It was found that the south spillway wall that was still standing had settled about 5 ft., the north end of the spillway weir about 7 ft. and the rock-fill and masonry parapet walls about 9 ft. The rock-fill still held together practically intact. Large sections of the spillway walls, some containing several yards of masonry, had been carried to the river bed below. The rock-fill on the undamaged portion of the dam showed an average settlement of 0.25-ft., the earth fill about 0.3-ft., except in one place where both front and back walls had settled over 0.5-ft. How much of the buildings settled cannot be accurately told, but it amounts to several feet.

I am convinced that the repair work of the week before had stopped the leak around the north end of the dam. Also that the earth covering put over the lava rock was an effective measure. If all the rock at the south end had been similiarly blanketed the situation might have been averted.

The stream below the dam gave no warning of anything wrong at the south end until the morning of Sept. 6. The water in the reservoir was then so high that work was practically prevented. Earth excavated from the spillway had been used in places for this very purpose. The water finding some channel under the lava capping washed out the fine sand which everywhere lies just beneath the lava. The rock settling caused the small slip of the earth fill and the whirlpools noted. The channels becoming larger and larger sluiced out the underlying sand and the rapid settlement resulted.

Water now stands at El. 982, or 30 ft. above the floor of the tunnel, having fallen about 18 ft. from the maximum height of Sept. 6.

In his letter to this journal Mr. Sanders mentioned no injury to the dam except at its south end. From his official report it appears that a 30-ft. section of the hydraulic-earth-fill near the north end of the dam was slightly damaged by a settlement of about 5 ft., which was caused by a leak through the rim-rock of the reservoir, near the point where the hydraulic-fill joins the natural rock underlying the north mesa.

Had it not been for the "excellent manner in which the rock-fill was constructed," Mr. Sanders reported, the reservoir would most certainly have been seriously damaged.

We quote further from Mr. Sanders' report as follows:

In no instance did water first find entrance through the dam. The lava formation through which it did find entrance was apparently the same as the formation which elsewhere encircled the rim of the reservoir, through which no leakage occurred and, in our opinion, the damage was therefore due to natural causes which could not have been reasonably anticipated by engineers in charge of the work and which could certainly not be charged to faulty construction as the entire work was of the most superior construction throughout and it is unquestionably

FIG. 3. LOOKING UP AGAINST THE LOWER OR ROCK FACE, AND SHOWING SETTLEMENT AT SOUTH END.
(This view also shows the lava rim-rock west of the spillway through which water was escaping from the reservoir during the investigation of the accident.)

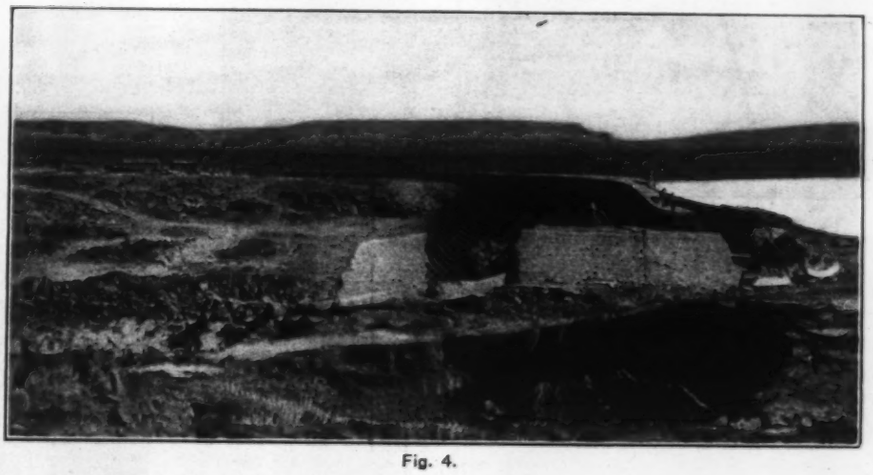


Fig. 4.

Fig. 5.

FIGS. 4 AND 5. LOOKING NORTH ACROSS THE LENGTH OF THE DAM, ALONG LOWER OR ROCK-FILL AND UPPER OR EARTH-FILL SIDES.
(In the foreground of Fig. 4 can be seen a sink hole on the south side of the spillway. Beyond is the ruptured south wall of the settled portion of the south abutment of the dam. The viewpoint for Fig. 5 is on the mesa, to the south of the spillway. The washed-out earth-fill is shown in this view, and also the settlement of the rock-fill.)

FIGS. 3 TO 5. GENERAL VIEWS OF ZUNI DAM AFTER UNDERMINING OF SPILLWAY AND SOUTH END BY WATER ON SEPT. 6, 1909.

FIG. 6. LOOKING WEST TOWARDS SOUTH ABUTMENT OF ZUNI DAM, SHOWING EARTH-FILL WASHED AWAY AND UPPER SIDE OF ROCK-FILL EXPOSED.

FIG. 7. LOOKING NORTH OVER LOWER SIDE OR ALONG ROCK FACE OF ZUNI DAM, AND SHOWING BASALTIC FOUNDATION UNDERNEATH THIS PORTION OF DAM.

FIGS. 6 AND 7. NEAR-BY VIEWS OF DAMAGED PORTION OF ZUNI DAM.

due to this fact that the reservoir was not damaged to a very much greater extent than reported herein.

The south abutment of the dam and spillway is the weak and dangerous part in the reservoir at present and early steps should be taken to repair this section to prevent further damage to the reservoir in the event that it should be visited again by a similar flood.

RECOMMENDATIONS.—In view of the uncertain character of the disrupted formation now underlying the south mesa and the district around and across the affected area any measures that may be taken to permanently repair the reservoir (without greatly reducing the reservoir capacity) must necessarily be very expensive. In our opinion no half way measures should be adopted in this case; the repairs should be made but once and for all time, and it is with this end in view that the following recommendations are respectfully submitted:

(1) That a new spillway [see plan, Fig. 1] 100 ft. wide, 8 ft. deep and about 200 ft. long be constructed, said spillway to have a carrying capacity under 6-ft. entrance head of 12,000 cu. ft. per sec., with a floor elevation at intake of 991, which is 9 ft. lower than the lip of the original spillway. The estimate submitted is for a concrete structure with reinforced-concrete side walls.

(2) That the settled portion of the rock-fill dam be reconstructed and extended 95 ft. farther to a junction with the north wall of the spillway when constructed.

(3) That to permanently cut off the underground flow from the reservoir during both high and low period, a reinforced-concrete cut-off wall be constructed, extending from a proper point in the hydraulic-fill for a distance of about 600 ft. across disrupted portions of the mesa, intercepting and joining at this point a ledge of rock which extends from the rim of the reservoir across the south mesa in a westerly direction and beyond which ledge no settlement or leakage from the reservoir has occurred.

This wall should form a water-tight connection with the floor and the walls of the spillway; it should be backfilled on either side with a suitable earth puddle, and should extend down to an impervious stratum of clay, which the data now at hand indicate to be about 48 ft.

The estimate submitted was based upon a battered wall properly reinforced, having an average thickness of 2 ft. and an average depth of 48 ft., and the amount of the rock and earth excavation was determined by test pits which were sunk along the center line of the proposed wall at different points.

(4) That to prevent a recurrence of the leaking through the rim-rock of the reservoir near the north end of the dam which was discovered and stopped by Mr. Ritter before much damage had occurred, it is further recommended that all of the rim-rock which stands in perpendicular ledges for a distance of 250 ft. north of the dam be blasted down to a proper slope and that said slope for a distance of 250 ft. be then well blanketed with earth which must be heavily riprapped to protect it from wave action which is excessive at this point.

This work if properly accomplished is deemed to be sufficient for the protection of the reservoir at the north end of the dam, as there was no indication of any settlement of the north mesa during the high water period just passed.

ESTIMATE.—The following is a general estimate of the approximate cost of making permanent repairs herein recommended:

Spillway excavation	$9,320	
Concrete construction	20,750	
		$30,070
Dam extension:		
Excavation	2,111	
Rock work, including riprap	9,651	
Hydraulic earth fill	3,351	
		15,113
Concrete cut-off wall:		
Excavation and back fill	43,528	
Concrete wall (reinforced)	31,995	
		75,523
North side protection		6,000
Engineering and contingencies		13,294
		$140,000

CONCLUSIONS.—(1) That in the course of our engineering experience, we have never seen a finer or better built structure of its class than is represented by the Zuni Dam under present conditions.

(2) That the disaster which we have endeavored to portray should not be charged to faulty construction or careless engineering, but to one of those natural occurrences like earthquakes, which could not reasonably be anticipated, or if anticipated at the time of the construction safeguarded against without such great additional expense as to practically prohibit construction.

(3) That the main portion of the dam is undamaged the damage being confined to rising section at the south abutment which rested on a basalt capping 20 ft. thick.

(4) That in our opinion the end of the dam is now in critical and dangerous condition and steps should be taken to repair this section before another flood.

(5) That in view of the urgent necessity of repairing this section of the dam and spillway without unnecessary delay the sum of $50,000 should be made immediately available for the purpose and should these repairs be prosecuted as herein recommended we are of the opinion that the material can be handled more economically and expeditiously if a Shannon excavator be used for the excavation work.

FIG. 8. MAIN ENTRANCE POINT OF WATER THAT CAUSED UNDERMINING OF ZUNI DAM.

(View taken from one of the points marked X on Fig. 1. The top soil was carried down and out by the escaping water. The ruptured north wall of the spillway shows in the distance, with the south end of the dam on the extreme right.)

Electric Railway Equipment.*

Economical Maintenance.†

In the material charges for maintenance, the car wheels (cast-iron) represent 15.23%; brakeshoes, 9.12%; and brake appliances (including all apparatus connected with the brakes, except the shoes), 3.34%. These three items represent 27.69% of the total for the car.

When it is realized that the outlay for brakeshoes is practically 10% of that for all material used on a car, the importance of giving this subject attention is apparent. The question of securing from the original casting the maximum wear consistent with safety and a reasonable consideration for "pull-ins," is recognized as a very important factor in economy. Close attention should be given to scrap shoes recovered; they should be weighed carefully and each foreman advised of the proportion of wear that should be secured. The adoption of the association standard in this item of material will prove economical.

The great multiplicity of truck designs and the probable difficulty of getting manufacturers to agree, is no doubt the reason why the standardization committee has not recommended a distance from the rail at which the brakeshoe should be carried. It seems to be generally recognized that shoes on street-car trucks have, in the past, been carried too low, and where shoes are hung from the frame adjustment is difficult for the varying loads. The proportion of scrap is greater than would be the case where with the shoe hung nearer to the horizontal center line of wheel.

As the time the repair men must give to this material is a considerable item, it is important that castings be clean and free from rough and uneven places, so that the least possible time is taken in changing shoes. As brakeshoe mixture has a direct bearing on braking and on wheel wear, it is important that shoes should be

*Abstract of the report of the Committee on Equipment presented at the annual meeting of the American Street and Interurban Railway Association, held at Denver, Colo., Oct 4. to 8. The report was composed mainly of individual papers on certain subjects by members of the committee.

†W. H. McAloney, Superintendent of Rolling Stock, Denver City Tramway, Denver, Colo.

made by foundries making a specialty of this class of work.

Braking pressure must vary directly as the weight of the car. Brakeshoe wear will vary directly as the braking pressure and the work accomplished, and it is therefore not considered as important for purposes of comparison to know the cost per 1,000 car-miles or ton-miles, as it is to know the "per cent. of metal worn."

Brake appliances, which include shoe heads, pins, hangers, levers, chain, handles, staffs, ratchets, etc., on hand brakes, as well as all apparatus pertaining to air brakes, while amounting in outlay to only about one-third that

FIG. 9. LOOKING NORTHWEST ACROSS UPPER END OF SPILLWAY OF ZUNI DAM, SHOWING RUPTURED FLOOR AND NORTH WALL, TOGETHER WITH LEANING PORTION OF SOUTH WALL ON THE LEFT.

of shoes, obviously are the most important features of a car and the more congested the traffic the greater the loss in all things if the brake and its operation is not modern.

There are not many of the so-called noiseless hangers in use, owing to the usual complication of pieces, and most lines have many of the ordinary link hangers with their annoying chattering noise on the streets after a little wear. To a very great extent it has become the practice to case harden all wearing parts of hangers, and when shoe heads are suspended by hangers, to bush the head when worn with case hardened steel tubing. It is also general practice to bush cylinder levers with case hardened steel tubing, and to case harden all brake-rigging pins. This is no doubt an important factor in economy and is recommended for general practice.

As an example, the average malleable shoe head is worth when new about 48 cts. When worn (if beam is suspended by hanger to head), it can be redrilled and bushed with case hardened steel tubing at a cost of about 16 cts., and can be returned for use with a life possibly exceeding that of the original.

For surface street railway cars, chilled cast-iron wheels have been most generally used, the rolled steel wheel probably not having been in use a sufficient length of time to demonstrate what service may be reasonably expected. Brakes and wheels are commended seriously for consideration as the energy stored in a rapidly moving heavy car, is absorbed in a few seconds through the wheel, by the use of the modern brake.

In mounting wheels it is important that great care be taken to see that the same tape sizes and shrinkages go on the same axle, and in the case of the two-motor equipment, it is equally important to see that the higher tape sizes be used on drivers. Wheels with different shrinkages on the same axle are frequently the cause of the ever-present thick and thin flanges which are sometimes charged to the "out-of-square truck."

A large percentage of "slid flats" are the result of using the reverse in making emergency stops, and we would recommend (as a feature toward economy and the abolition of a public nuisance) that on all cars having power brakes, reversing of motors should not be resorted to except in case of defective brake rigging.

Car Weights as Affecting Operating Costs.*

Within the past two years there has been an awakening of interest in the question whether the steady increase in the weights of electric cars has not involved (at least in some cases) an increase in expense of operation out of proportion to the advantages secured.

There has never been any doubt that more power is required to move a heavy car than a light one. But the feeling seems to have been general that power is about the cheapest item in the cost of operating a road, and that the increase in that item caused by any increase in size or weight of cars or equipment would, as a matter of course, be small as compared with advantages to be gained in other directions by the proposed change. When it is suggested that a decrease in the weight of cars might be brought about without sacrificing carrying weight or capacity, the question is at once raised whether the increased cost of building such lighter cars will not more than offset any saving to be effected in operating expenses.

Probably no argument is needed to show that an increase of car weight will cause an increase in the following items of expense: (1) cost of power; (2) cost of car repairs; (3) cost of track repairs; (4) fixed charges of power plant; (5) fixed charges of distribution system. It is not obvious, however, that these will increase proportionately to the weight of the car. The cost of power is divided into two portions, one which is independent of the weight of the car, and the other proportional to that weight.

An increase in car weight involves an increase in the weight and cost of all replacement parts, this cost being nearly but not quite proportional to the weight. If the increase of weight is accompanied by proportional increase of strength and bearing surfaces, the life of parts should not be decreased, the sole increased cost of repairs being due to the greater cost of replacement parts. However, such proportional increase is not possible in many parts, such as trolley wheels, gears, brakeshoes and wheels, all of which wear out much faster with heavy cars than with light ones. On the other hand, some items of car repairs are independent of weight, such as painting and replacing glass.

It is evident that a certain part of the cost of track repairs would be incurred irrespective of use, as decay of ties and corrosion of metals, and injury from teaming would go on just the same. Otherwise, wear is evidently about proportional to ton mileage. If the track construction is much too light for the car weight, the wear would increase faster than the weight, but with tracks suitable to the traffic, it is probably closely proportional.

While the cost of carrying around weight will vary in each case, it is believed that the figure of 7.5 cts. per lb. per year is a fair average value and by no means an extreme case. There is a general tendency in several large city systems to estimate it at 5 cts. per lb. per year. This is not at all inconsistent with the figure of 7.5 cts. above given, which corresponds more nearly with interurban conditions. Even at 5 cts. per lb. per year, we can afford to pay $1,000 per ton for a reduction in car weights.

At this figure, if we could reduce the weight of a 28-ton car to 14 tons, without reducing its carrying capacity, safety or speed, we could afford to pay $14,000 more for the lighter car. Even if a much lower figure than $1,000 per ton is taken, it is evident that it will still pay to spend a great deal of time and money in solving the problems of producing lighter cars.

The weight of any electric car is partly due to its electrical apparatus, and it is interesting to inquire how great a proportion of the total weight must be assigned to this purpose. From figures plotted it is evident that there is no relation between the weight of car and the HP. per ton, but in practically all cases the latter falls between 5 and 10.2 HP. per ton. Of two extreme cases (3 and 12.3 HP. per ton) the former is a light 16-ft. box car with one motor, and the latter is an English tunnel car for train operation, probably intended to be used with trailers.

The fact that the average car body is only 43% of the whole weight of the car should not lead to the conclusion that a reduction in the weight of car body itself is comparatively unimportant, because that can and should be accompanied by a nearly proportional reduction in the weight of motors and trucks.

While of course no detail is too small to be of importance, it appears that miscellaneous fittings do not constitute a very large part of the weight. The car body itself is the best place to start to reduce weight. A lighter car body permits lighter trucks. Lighter trucks and car body require less power to move and therefore call for lighter motors.

Interest in the subject of reducing car weights seems to have been rapidly developing during the past year or two. A number of operating companies have been investigating methods and have made encouraging progress. One company has designed a malleable-iron body bolster to take the place of a built-up steel plate bolster for its standard cars. The new bolster is shown by test to be much stronger than the old one, but is 109 lbs. lighter, making a reduction of 218 lbs. per car, which is a saving worth (at the average value above estimated) about $156 per car.

Another company has just contracted for new cars which are 2 ft. longer than their old standard, and 2,000 lbs. lighter, besides being undoubtedly stronger. This result is attained by a partial steel frame construction and the use of a turtleback roof in place of the monitor deck.

One large eastern company has closed contracts for cars and trucks, after receiving bids upon specifications drawn to emphasize the importance of light weight. The contracts finally signed specify weight limits which must not be exceeded, and include agreements on the part of the builders to furnish the customer with detailed weights of each and every component part as actually

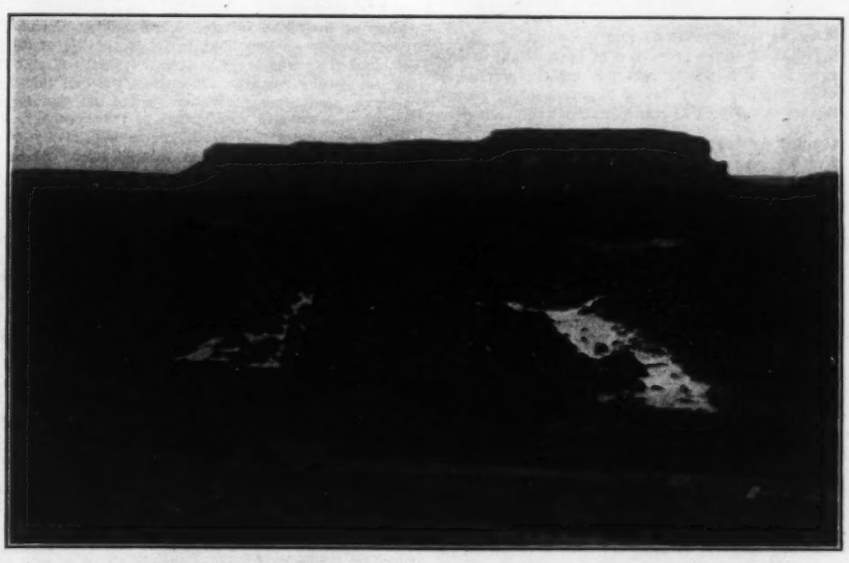


FIG. 10. LOOKING SOUTH ACROSS WASHOUT OF SPILLWAY OF ZUNI DAM; ALSO SHOWING POINTS WHERE WATER ESCAPED UNDERNEATH LAVA CAPPING OF THE MESA AND SPILLWAY.

*Milan V. Ayres, Electrical and Mechanical Engineer, Boston & Worcester St. Ry., Boston, Mass.

constructed. As a result, the new cars are to be 4,000 lbs. lighter than cars of the same size now in use by the company.

The double-truck car body may be regarded as a bridge structure supported at the bolsters and overhung at both ends. The two car sides can be designed as trusses, resting upon and connected together by the bolsters, which are themselves shallow trusses carrying the load to the center plates. This elementary truss frame can be designed so as to be extremely light and still be amply strong to bear its load. The simplicity of the problem is badly interfered with by the necessity for platforms, which are very awkward to attach and disproportionately heavy, and become more troublesome as their length is increased. The problem is still further complicated by the necessity of providing for drawbar strains, and the uncertainty as to the strains set up by the motion of the car.

It is probable that the correct principle in designing cars for lightness is to provide first a strong steel frame to take the known strains, and secondly to use the lightest possible material for all parts.

In every case brought to light in this investigation, where car weights have been reduced, this has been accomplished, at least in part, by the use of steel in place of wood. The fact is that weight for weight, in almost all forms, steel is stronger than wood, the superiority becoming very pronounced in some special shapes, such as I-beams, to which steel is especially adapted. This is true of ordinary structural steel, and some of the special alloy steels are even very much stronger and undoubtedly can be advantageously used in some places.

Hard wood is heavy material. For some purposes a light wood can be used equally well, and probably some form of fiber in thin sheets can take the place of wooden panels with much saving of weight. Aluminum can be used in sheets for siding and as castings to take the place of bronze fittings. Common cast iron should be excluded altogether from car construction. It has no use for which some other material would not be lighter and better.

In the matter of truck construction, probably pressed steel can be utilized to reduce weight to a marked degree. Hollow axles of high-strength steel are also a hopeful possibility.

Electric equipment can undoubtedly be reduced in weight. Probably the greatest reduction can be accomplished by designing motors for large commutating capacity and using forced ventilation. It is possible that radically new designs may be made, permitting of lighter construction. Perhaps a combined motor and truck built as one machine may solve some of the motor and truck problems.

In the ordinary electric passenger car, the dead weight is from three to ten times the live weight when all the seats are occupied, while the average condition of loading would show a much larger proportion of dead weight. In other words, the weight efficiency is not better than from 10 to 30% under the best conditions, and drops to nearly nothing under the worst.

The reduction of the proportion of dead weight to passengers carried seems to hold out greater promise of economy than any other line of improvement at present discernible in the field of transportation engineering.

Steel-Tired and Rolled-Steel Wheels.*

Many of the smaller roads are still using chilled cast wheels even in interurban service. Many of the larger companies are coming to the use of the rolled-steel wheel, deeming it safer and more economical. One large company has entirely eliminated the use of steel-tired wheels and substituted rolled-steel wheels.

STEEL-TIRED WHEELS.—The average tire is about 3 ins. thick, and gives about 2 ins. wear. In doing this the wheels are given from two to four turnings, and the approximate mileage between each turning is shown to average about 40,000 miles. Some roads allow the tires to run to a thickness of ⅞-in. before they consider them unsafe, but the majority consider 1¼ ins. as the limit. It is noticeable that those which use the ⅞-in. limit have considerable trouble with loose tires. This refers to fused tires and where retaining rings are used, and not to the bolted type. Of the various types of tire fastenings, the majority favor the double lip retaining ring of the riveted or bolted type.

Only one company states that it has any broken centers and this company is using a cast-iron center. While 17 out of 35 companies are using cast-iron centers, 18 are using cast steel. None of them report trouble with broken centers where cast steel is used.

ROLLED STEEL WHEELS.—The outside diameter of the wheels when new is 30 to 37¼ ins., with rims 2 to 3¾ ins. thick. Some roads use them down to a limit of ¾-in., while others are using only to about 1½ ins. This, however, is in the case of some of the smaller roads. On many roads they are worn to a thickness of ¾-in. when scrapped, while several companies have a limit of ½-in. With the exception of a few smaller roads (as mentioned above) the others use 1¼ ins., the same as has been customary with the heavier type of steel-tired wheel. The average shows that ¾-in. thickness with the rolled-steel wheel seems to be considered perfectly safe.

The average number of turnings is three, but one of the large companies gives ten. This company gets 10,500 miles between each turning. The rest of the companies give their wheels from three to four turnings and obtain an average of about 30,000 to 35,000 miles between each turning. Nearly all the roads find the last turning slightly softer. As to safety and economy (scrap considered) for high-speed interurban service, nearly all the 50 roads considered the rolled-steel wheel superior to the steel-tired wheel.

It would seem reasonable, especially from a safety standpoint, that a one-piece wheel would be preferred to a wheel made from several pieces or sections assembled together. On the other hand, while the manufacturers contend that the rim of a rolled-steel wheel is as homogeneous as a steel tire, the data from the railway companies show that they find the last turning of these rims slightly softer than the first. It also shows that these rims can be worn to a greater amount with safety than can the steel tire.

The shop conditions in this case should also be taken into consideration, as many of the smaller roads are not equipped for removing and resetting the entire wheel, but can readily remove and reset a steel tire. Owing to the considerable amount of machine work that is required on steel tires, it would seem that the cost of a rolled-steel wheel would not greatly exceed that of a steel tire, while the scrap value is all in favor of the rolled-steel wheel.

It would seem, however, that in the rolling of a tire the metal would be more homogeneous and evenly tempered throughout, as the rolling can be applied both to the inner and outer surfaces as well as to the sides, while with the rim of a rolled-steel wheel this cannot be done.

In comparing mileages, the data show that as to wearing qualities, the wheels are about equal and that the limit of wear of the rolled-steel wheel rim can exceed that of a steel tire safely. This would offset the softness of the last turning, before mentioned.

It is very common practice for interurban companies to allow the flanges to run until they are dangerously sharp. This is false economy, as, in this way so much metal has to be removed in turning to again bring the tread and flange to its proper shape, that the loss of metal is much greater than would be necessary were the wheels turned at the proper time.

Trucks should also be considered an important feature in the saving of wheel flanges. While from ordinary inspection it might appear that the truck was in fair condition, the placing of a tram diagonally across the truck from center to center of journal box may show the truck to be out of square. This also has a great deal to do with sharp flanges or the crowding of wheels.

Any of the above defects, to say nothing of bad track conditions, is an important factor in the life or mileage obtained from wheels. The great advantage of standards to the railway company arises from the fact that fewer designs mean lower production cost to the manufacturer and correspondingly lower prices to the consumer. Manufacturers advise that much of the multiplicity of designs arises from differences in dimensions which are trivial.

*L. W. Jacques, Master Mechanic, Fort Wayne & Wabash Valley Ry., Fort Wayne, Ind.

Heat-Treated Carbon Steel Axles.*

The original motor-car axles installed in 1902 on the Manhattan Division of the Interborough Rapid Transit Ry. (New York), have been in process of failure, which failure began at approximately 250,000 miles, and would have been concluded at about 350,000 miles if not prevented and removed by inspection. The fiber stress was normal, and the best axle material known at that time was employed. The failure is characterized as "fatigue of metal," and in appearance is a "detail fracture," or a gradual separation of particles of steel.

Standard locomotive driving-axle material was used on these motor cars, and although this material performs satisfactorily in steam railway service, it has proved to be a failure in this and other electric-traction service. The vibration set up in axle structures through the medium of spur-gear methods of power transmission may be the principal cause for these failures. These failures were detected by a system of inspection before breakages occurred, and the axles were replaced by heat-treated axles, after careful study of the subject.

The specifications for heat-treated axles installed on the Manhattan Division are rather rigid, such as it was thought might prove too expensive and difficult of manufacture for general practice. A conference was held July 22, 1909, for the purpose of obtaining opinion on a form of specification that would be best suited to meet the general requirements of electric traction service on equipments containing motors of 100 HP. or more. Leading metallurgical engineers and representatives of the steel industries of this country attended the meeting and agreed upon a form of specification for heat-treated axles.

Process of Manufacture.—It was agreed unanimously at the meeting that axles for the class of service under discussion should be forged of open-hearth steel (acid or basic), and that a treated axle is far superior to the untreated type. Heat-treated axles are allowed to cool after forging, then reheated to proper temperature, quenched in some medium, allowed to cool, and then reheated to the proper temperature for annealing.

Impurities.—The maximum limit of phosphorus to be 0.04% for basic open-hearth steel and 0.05% for acid open-hearth steel. It was agreed that the sulphur content affected the manufacturing processes only and was not deleterious to the consumer.

Manganese Content.—Mr. Bostwick (Carnegie Steel Co.) and Mr. Acker (Bethlehem Steel Co.) thought that 0.60% was too low a limit, both stating that 0.70% or higher would be better, as it would aid the steel manufacturer to obtain the elastic limit. This was better than to raise the carbon content, as manganese is a substance which does not segregate, while carbon does. Mr. Bostwick further stated that whenever his company has to meet a specification that is very strict in its requirements, it endeavors to keep the manganese content high and the carbon content low. Mr. Acker, Mr. Bostwick and Mr. Sargent (Carpenter Steel Co.) all felt that 0.80% would be a good maximum limit for manganese, Mr. Sargent stating that, in his opinion, this would give a stronger steel than one having a higher per cent. of carbon and lower percentage of manganese.

Discard.—All present recommended not specifying the exact amount of discard and that the specifications should make this feature automatic. That is to say, if the specifications state that the tensile test piece and drillings for analysis are to be taken midway between the center and the outside of the section, the manufacturers, of necessity, would have to be careful to see that steel used in all the axles would be free from piping or segregation, and, therefore, they would have to make an adequate discard in order to meet the physical requirements of the specifications. Attention was drawn to the fact that the axle picked out for test might not have been made from the upper part of the ingot, but the representatives of the steel manufacturers all stated that there was an equal chance that it might have been, and, therefore, the manufacturer would stand in danger of having all his axles rejected. It was agreed that the specifications should read as follows:

"Sufficient discard must be made from top of ingot to insure freedom from piping and undue segregation."

Physical Properties.—The specifications of the American Society for Testing Materials for heat-treated steel forgings provide as follows: Tensile strength, 80,000 lbs. per sq. in.; elastic limit, 45,000 lbs.; elongation in 2 ins., 23%; reduction of area, 40%.

The question was then brought up whether the ultimate strength should be specified. Mr. Acker favored this course, stating that the yield point as determined by drop of beam was always a matter of some doubt, varying as much as 5,000 lbs. per sq. in., depending upon the machine used, speed of the feed and the operator. The ultimate strength, together with the elongation and reduction specified, would very closely determine the elastic limit. Messrs. Bostwick and Stevenson (Standard Steel

*J. S. Doyle, Interborough Rapid Transit Co., New York.

COMPARISON OF SPECIFICATIONS FOR DRIVING AXLES FOR ELECTRIC MOTOR TRUCKS.

	Old Manhattan Elevated.	Interboro R. T. Co. Standard.	Proposed.
Carbon	0.40 to 0.55	As low as possible.	.....
Manganese	Not above 0.70.	Not above 0.60.	Not above 0.80.
Phosphorus	Not above 0.05.	Not above 0.04.	Not above 0.04 for basic and 0.05 for acid.
Silicon	Not above 0.25.	.....	.....
Sulphur	Not above 0.04.	Not above 0.04.	Not above 0.03.
Ultimate strength, lbs. per sq. in.	80,000	.....	80,000
Elastic limit, lbs. per sq. in.	40,000	50,000	45,000
Elongation in 2 ins., per cent.	20	22	22
Reduction in area, per cent.	.....	45	40
Discard, per cent.	30	30	Made automatic by location of test pieces.
Treatment	Slow-cooled by burying in dry ashes when hot from hammer.	Quenched in oil and annealed by reheating.	Quenched in some medium and annealed by reheating.
Location of test piece	Midway between center and outside.	Midway between center and outside.	Midway between center and outside.

Co.) favored laying greater stress upon the elastic limit, meaning thereby not the true elastic limit, but the yield point as determined by drop of beam and check movement of dividers.

Mr. Acker recommended the following: Tensile strength, 85,000 lbs.; elastic limit by extensometer, 50,000 lbs.; elongation, 20%; reduction, 40%. Messrs. Stevens and Bostwick both expressed the opinion that this specification was too rigid and was at the very limit of the properties that could be obtained and would prove a great hardship to the manufacturer. Attention was then called to the fact that the object of drawing up a standard specification was to provide to the consumer a material much better than that which he is now using, but at the same time to provide one which could be produced by the manufacturer on a reasonably commercial basis.

After some little discussion all of the steel manufacturers present agreed that the following specifications would be satisfactory: Tensile strength, 80,000 lbs.; yield point by drop of beam, 45,000 lbs.; elongation in 2 ins., 20%; reduction of area, 40%.

Discussion.

A written discussion from Mr. John Lindall, Superintendent of Shops of the Boston Elevated Ry., suggested that in reducing the weight of cars care must be taken not to reduce the strength and so cause failures. Many cars are undoubtedly too heavy, due partly to lack of appreciation of the relation of weight to power consumption, and partly to unsystematic repairs. If a failure occurs, the parts are likely to be strengthened arbitrarily, without considering the proper design and construction. Mr. Martin Schreiber (Newark, N. J.) remarked that car weights are often increased without consideration as to bridges or track. Some time ago, the question came up on his road whether to operate a certain line with five 20-ton cars or four 40-ton cars. A study of the traffic conditions and current consumption showed results favorable to the heavier cars, but it was found that bridges would have to be strengthened to carry them. The use of "prepayment" cars has introduced a new trouble, due to the clearance required by the long platforms in passing curves. The cars cannot pass on curves, but one must wait, thus interfering with schedules.

Mr. McAloney, of the Denver Tramway Co., was asked as to the success of the light cars used in Denver, and replied that all of them were found of sufficient strength to carry full loads and do their work economically. Mr. W. H. Evans (Buffalo, N. Y.) said that for the past few years the tendency had been to build cars of greater weight than required by the conditions, and also to use extra and superfluous appliances. In examining a recent design for cars, he found that if the cars were operated always from one end, appliances aggregating 2,334 lbs. could be removed. Mr. E. W. Holst (Boston & Northern Street Ry.) had reduced a car body design to 14,000 lbs. and trucks from 14,200 lbs. to 12,000 lbs. The electrical equipment (14,250 lbs.) was the most difficult, but was reduced about 250 lbs. by changes in the gear case and the use of pressed steel in place of cast iron. Mr. Ayres considered that while a reduction in weight can be effected without making radical changes, a greater reduction can be made in conjunction with such changes. He did not approve of the "prepayment" type of car, which is necessarily heavy, but was much impressed by the side (middle) entrance, single end cars used in Denver.

The committee had recommended certain standard dimensions for rolled-steel wheels of different diameters, and on motion of Mr. McAloney these were referred to the committee on standards. The committee had also recommended a change from the present standard flange contour to that of the M. C. B. wheels, but on motion of Mr. Schreiber this recommendation was struck out of the report.

As to axles, Mr. Barba, of the Midvale Steel Co., stated that his company has supplied 700 axles to the Interborough Ry. which were made to Mr. Doyle's specifications for that railway, and the results of the tests were much higher than the requirements. Axles can be made having 55,000 lbs. elastic limit and 23 to 24% elongation, and he favored raising the requirements of the above specifications. Axles of untreated steel which will break at about 30° in a cold bending test, can be given a heat treatment which will enable them to bend flat when cold. Mr. J. L. Replogle, of the Cambria Iron Co., supported Mr. Barba's remarks in favor of stiffer requirements than those of the present specifications of the Interborough Ry., and thought it well to specify the weight of hammer. For work of this kind it should be not less than 10,000 lbs., to ensure the action penetrating to the center of the forging, and his company is using 15,000-lb. hammers. Mr. Roberts, of the Northern Ohio Traction Co., stated that recently he had purchased a number of complete trucks, and that the breakages of axles became so serious that all the axles were rejected. The new ones are of heat-treated steel, and no breaks have occurred. These breakages were next to the gears. The new axles are of heat-treated steel, with the gear seat ½-in. larger in diameter than the main part of the axle; no breaks have occurred.

The specifications for axles of heat-treated steel were referred back to the committee for further consideration.

An Unique Direct-Acting Explosion Pump.

A pump of striking originality of design and of remarkable efficiency has recently been developed by Mr. H. A. Humphrey, M. Inst. C. E., 38 Victoria St., London, E. C., a well known English engineer. This pump has neither piston nor cylinder, in the true meaning of these terms, as the water serves as the one and the waterway as the other. The pumping is done with approximately 1 lb. of coal per water horse power in comparison with 2 lbs. for compound high-duty steam engines, 1.7 lbs for triple-expansion engines, and 1.6 lbs.

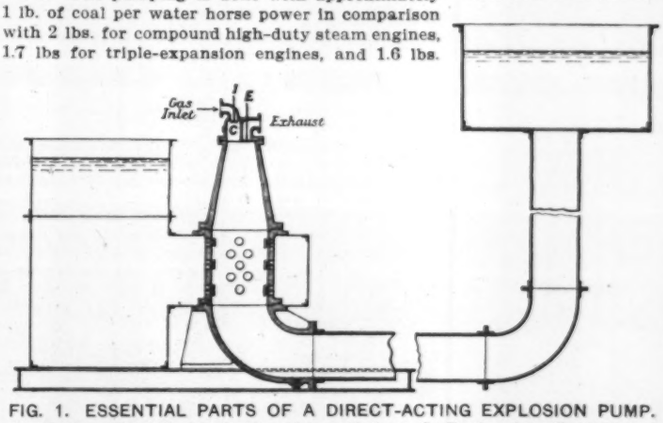


FIG. 1. ESSENTIAL PARTS OF A DIRECT-ACTING EXPLOSION PUMP.
(Designed by Mr. H. A. Humphrey, M. Inst. C. E., London, England.)

for a gas-engine driving a centrifugal pump. The Humphrey design is described in London "Engineering" of Oct. 15, and a report of a test by Prof. Unwin is reprinted. Portions of the article and of the report are reprinted in what follows:

The essential features of Mr. Humphrey's pump are shown in Fig. 1. It consists, it will be seen, of an U tube having legs of unequal length. The shorter leg is partially immersed in a tank, from which is drawn the water to be pumped, while the larger leg enters, at the bottom, the tank to which the water pumped is to be delivered. Admission check-valves for the water are provided below the water level in the suction tank as indicated. The portion of this leg above the water level in the tank forms the combustion chamber, the valve I being the admission valve, and the valve E the exhaust valve. In addition to these there is a third, a scavenger valve, not shown in the diagram.

Assuming the pump to have been started, a manœuver which is very easily effected as later shown, the sequence of events is as follows: A charge of gas and air entrapped in the space C is under compression, and is fired by an electric spark. This sets in motion the water in the long leg of the U, which forms an essential component of the pump. This water acquires a momentum so great that it continues to flow after the pressure of the gases above it has been reduced to that of the atmosphere, and at this point the exhaust valve opens by its own weight. The column still continuing to move, water flows in from the suction tank through the valves mentioned, partly to follow the moving column and partly to rise in the combustion chamber, so as to keep the water level inside the chamber nearly the same as that in the tank. There is, in fact, at this period a slight vacuum inside the chamber, so that air enters the top of it through a special automatic scavenger valve already mentioned, with the result that the whole space at the top of this vessel is filled with pure air. Finally, the water column having expended its acquired momentum, begins to flow back under the static head due to the position of the delivery tank, since the pressure in the combustion chamber is now atmospheric. The water which has been drawn into the system from the suction tank is therefore forced back towards the combustion chamber. In this backward flow it expels through the exhaust valve the spent gases, and on reaching the level of the exhaust valve closes it, a locking bar coming then automatically into operation to prevent this valve opening subsequently, before its appointed time. With the momentum acquired during this period on its backward flow the column of water continues to rise, compressing the air entrapped in the space C above it, to a pressure considerably in excess of that corresponding to the static head. The result is that the motion of the column is again reversed, and fresh momentum acquired, which again causes the pressure in the combustion chamber to fall below the atmospheric. At this moment the inlet valve I opens, and a charge of air and gas is drawn in, while the water column continues its motion into the delivery tank. Finally, however, its forward momentum being again expended, it oscillates back into the combustion chamber, compressing the charge there to a pressure which is again in excess of that due to the static head. When the desired compression is attained, the mixture is ignited, and a fresh cycle of operations is begun. The cycle, it will be seen, consists, therefore, of a long expansion stroke, in which the pressure falls to a little below that of the atmosphere, and water is drawn in from the suction tank, and air through the scavenger valve. This is followed by a long return stroke, during which the products of combustion are expelled. After this comes a short suction stroke, in which a fresh charge is drawn in; and, finally, a short compression stroke at the end of which the charge is ignited. The pump operates, therefore, on a four-stroke cycle, the strokes being unequal in length. It has, indeed, been found possible to utilize the ordinary ignition set as used in motor-car work, consisting of a couple of cells, a trembler coil, and an ordinary plug. With this there are absolutely no misfires. Moreover, direct experiment has proved that a single missed ignition will not stop the working of the pump.

The plant at Dudley Port, on which Professor Unwin's tests were made, is, for an internal combustion plant, remarkably free from noise. The principal sound is due to the rush of air through the scavenger valve, which was not fitted with a silencer. The exhaust, being effected at atmospheric pressure, is practically noiseless and requires no silencer.

The only moving parts are the light automatic valves (which at Dudley Port have run for a week at a time without lubrication) and the small spring-loaded piston, which times the ignition. The inlet, scavenger, and exhaust valves are coupled up by an automatic interlocking gear, which is shown in Fig. 3.

This interlocking gear is required, since all the valves operate automatically, and therefore, unless some special provision were made to prevent it, the exhaust and admission valves would open simultaneously. The locking bar, lettered *a* in Figs. 2 and 3, slides to and fro between the two valve stems under the influence of the springs *b* and *c*, which are alternately set in tension by the motion of the rocking lever *d* below. This frame is rocked alternately one way or the other by the projecting collars, *e*, *e* mounted in the valve stems. In Fig. 2 the apparatus is represented set in position, with the exhaust valve E open. In the descent of this valve its collar *e* has forced over the rocking lever *d*, and once the latter has "passed its center" it is held in position by the spring *g*. In this position it puts the spring *b* in tension, so that the locking bar *a* tends to move to the right from under the screw collar on the admission valve stem. It cannot, however, escape from under this collar until the exhaust valve E has returned to its seat, but so soon as this valve is closed, the spring *b* moves the locking bar over so as to come under the collar on the exhaust valve stem. The latter is therefore held up, but the admission valve is now free, and when a partial vacuum is afresh established in the combustion chamber, this admission valve alone is able to open. In the descent of this valve it shifts the rocking lever *d* over to the other side of its center of oscillation, in which position it is again held by the spring *g*. The spring *c* is now in tension, and thus tends to unlock the exhaust valve stem, but cannot move over till the admission valve has returned to its seat.

The ignition gear consists essentially of a spring-loaded piston, the rod of which passes between two friction wheels, which are pressed on to the rod by the action of

springs. As the rod rises, therefore, these wheels rotate. Affixed to one of the wheels by a friction grip is a small contact-making lever, the arc of oscillation of which is limited by stops. As a consequence, while the pressure inside the combustion chamber is rising, and the rod is consequently moving upwards, this contact lever is pressed against its lower stop. The instant, however, the pressure has reached its maximum and begins to diminish again, the contact-making lever is flung over against its upper stop and fires the charge. Provision is also made by which the charge can, if desired, be fired so soon as the compression reaches a predetermined value.

The combustion chamber is always cold to the touch. Starting up the plant is quite a simple operation. After an ordinary stop made by switching off the ignition current, the combustion chamber is left with a charge of gas and air inside it, and the pump is then restarted merely by igniting this. In a start up, *ab initio*, the process, though longer, is nearly equally simple. Air is compressed in above the water surface in the combustion chamber so as to lower the water level there to about that of the water surface in the suction tank. The exhaust valve is then thrown open by hand. The water column then rises in the combustion chamber, compresses the air

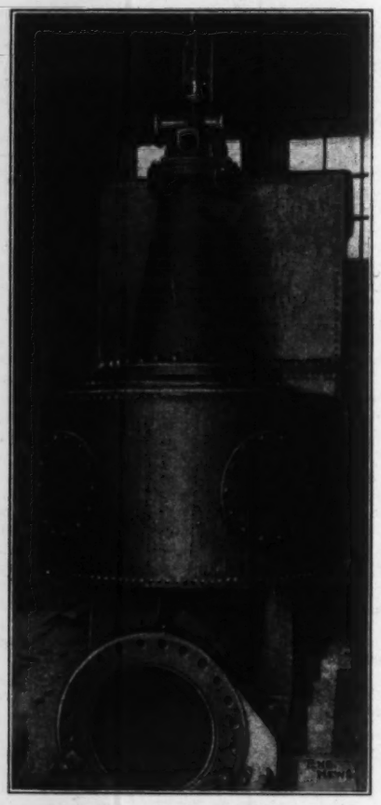


Fig. 2. Combustion Chamber, Valve Gear and Water Intake of the Humphrey Explosion Pump.

entrapped there, then moves back again, and draws in a charge, which is subsequently compressed and fired in the ordinary way.

Many other adaptations of this method of utilizing the heat energy of gaseous fuel have been worked out by Mr. Humphrey, and of these, we understand, he proposes shortly to publish particulars.

Prof. W. C. Unwin's Report.

I attended at Dudley Port on Sept. 21 and 22 and made careful tests of the gas-pumping arrangement of a completely new type which has been erected there. The pump is worked by the explosion of Mond producer-gas supplied from the works at Dudley Port. It worked absolutely automatically, without attention, when once adjusted, and started with a charge of compressed air with the greatest ease and certainty. Starting all cold, an explosion occurred in five seconds, and the pump continued working regularly. The pump worked throughout the trials, with varying lift, without any change in the gas and air mixture or any alteration in the cushion volume. Also without a single misfire or hitch of any description.

The results are very remarkable. The fuel consumption in these trials, reckoned on the work done in lifting water, was less than in any pumping arrangement, either by gas or steam, hitherto recorded.

ARRANGEMENT OF APPARATUS.—The arrangements for the trial were very satisfactory. The gas was supplied from a gas-holder, which, during a trial, was shut off from the gas main. The amount of gas used was determined from the fall of the gas holder during 10 or 12 minutes, the pressure and temperature being noted and the gas assumed to be saturated with moisture. The water in the gas-holder tank was maintained at the same level by securing a small, steady overflow throughout the time of the trials.

TABLE I.—WATER LIFTED BY HUMPHREY PUMP.

Trial No.	Head over orifice, ft.	Volume pumped. Cu. ft. per sec.	Volume pumped. Gals. per min.	Mean lift, ft.	P. HP. actual HP. water lifted.	Cycles per min.	Gals. per cycle.
I.	3.90	4.339	1,624	32.91	16.20	13.9	117
II.	3.77	4.267	1,597	32.89	15.92	13.9	115
III.	3.82	4.293	1,607	32.84	15.99	13.9	115
IV.	4.01	4.398	1,647	32.86	16.39	13.7	120
V.	3.92	4.350	1,629	32.91	16.24	13.7	119
VI.	3.90	4.339	1,624	32.81	16.15	13.7	118
Mean....	3.89	4.331	1,621	32.87	16.15	13.8	117
VII.	3.74	4.249	1,591	26.23	12.64	12.1	132
VIII.	3.54	4.132	1,547	25.71	12.05	11.8	131
IX.	3.61	4.174	1,563	25.92	12.27	11.5	136
Mean....	3.63	4.185	1,567	25.95	12.320	11.8	133
X.	4.43	4.625	1,731	20.54	10.78	11.6	150
XI.	4.69	4.759	1,782	20.80	11.23	11.2	159
XII.	4.45	4.636	1,735	20.84	10.96	11.5	151
Mean....	4.52	4.666	1,749	20.727	10.990	11.4	153

The explosion chamber with its suction valves communicated with a discharge pipe 135 ft. in length and 2 ft. in diameter. This discharged into a very large air vessel. At the outlet from this was a sluice valve, at which a man was stationed, opposite a pressure gage. By slight adjustments of the sluice he secured the maintenance of a nearly constant pressure in the large air vessel. The lift was measured by a mercury gage, one leg of which was connected to the suction tank, and the other to the water in the large air vessel. The difference of level of the mercury columns was a direct measure of the height of lift of the pump.

From the large air vessel the water passed through a second smaller air vessel to a measuring tank with stilling screens. In the bottom of this was a 9-in. sharp-edged orifice, through which the water fell back into the water reservoir supplying the suction tank. The head over the orifice, taken at about 1½-minute intervals during a trial, afforded a means of determining the pump discharge.

The pump ran continuously during the morning and during the afternoon, the lift being maintained constant during the whole period of each series of tests. The tests were necessarily intermittent, as the gas-holder required refilling at short intervals, the pump being connected directly to the gas main while refilling the gas holder. In the morning, with the greater lift, the duration of each test of the series was ten minutes. In the afternoon, with smaller lifts, the duration of each test was 12 minutes.

WATER LIFTED.—The values of head over orifice for each test are the means of seven to nine observations during each trial, the pump running continuously and steadily both during the trials and the intervals between the trials. The volume of discharge was calculated by the formula:

$$Q = c\,w\,\sqrt{2\,g\,h}, \text{ cu. ft. per sec.} = 2.197\,\sqrt{h},$$

and are shown in Table I.

PUMP HORSE-POWER.—The lift was observed on a mercury siphon gage, one leg of which communicated with the suction tank of the pump, the other with the large air vessel into which the pump delivered.

The pump horse-power for a discharge Q, cubic feet per second, and a lift of H, feet, was calculated by:

P. HP. = G.Q.H./550.
= 62.4 Q.H./550.
= 0.11344 Q.H., and the results appear in Table I.

The lift was observed from seven to nine times in each trial and the mean taken.

The temperature of the water pumped was 16° C., and the density of the water 62.4 lbs. per cu. ft.

GAS CONSUMPTION.—The consumption of Mond gas was determined by noting the fall of the gas holder in a definite time. A test for leakage was made on the 22d, and the gas valves were found to be tight. The pressure in the gas holder was indicated by a water siphon gage, and the temperature by a thermometer in the pipe leading to the explosion chamber.

The circumference of the gas holder was measured by a thin wire. Allowing for the plate thickness and wire diameter, the internal diameter was 8.5 ft. Probably allowing for rivet-heads, stays, etc., this value is more likely to be slightly in excess than in defect, the error being unfavorable to the engine. The horizontal area of the gas holder is therefore 56.75 sq. ft. A rigid pointer moving over a well-graduated metal scale was used to determine the position of the gas holder. These data are tabulated in Table II.

From chemical analyses the calorific value per cubic foot has been estimated, assuming the water vapor not condensed and the net calorific values of dry gases burned at constant pressure, B. T. U. per cu. ft. at 0° C. and 760 mm. pressure, as:

CO	342.4
H_2	292.8
CH_4	963.0

TABLE II.—GAS USED IN HUMPHREY PUMP TRIALS.

Trial number.	Duration, min.	Fall of gas holder, ft.	Gas pressure by water gage.	Absolute pressure, ins. of mercury.	Temperature of gas, C.	Cu. ft. of moist gas.	Cu. ft. gas per min. corrected to 0° C. and 760 mm.	Gas per hr. per P. HP.
I.	10	4.36	2.5	29.63	20	247.2	22.50	82.62
II.	10	4.40	2.6	29.64	20.1	249.5	22.72	84.78
III.	10	4.37	2.7	29.65	20.1	247.7	22.55	83.76
IV.	10	4.40	2.9	29.66	20.1	249.5	22.71	82.38
V.	10	4.32	2.7	29.65	20.1	244.9	22.28	81.60
VI.	10	4.40	2.8	29.66	20.2	249.5	22.59	83.58
Mean	..	....	...	.....	....	.....	22.508	83.12
VII.	12	4.32	2.8	29.66	20.7	244.9	18.[illegible]	87.08
VIII.	12	4.41	2.8	29.66	20.7	250	18.[illegible]	93.24
IX.	12	4.45	2.8	29.66	20.6	252.3	18.[illegible]	92.46
Mean	..	....	...	.....	....	.....	18.[illegible]	90.93
X.	12	3.97	2.8	29.66	20.5	225.1	16.[illegible]	93.96
XI.	12	4.09	2.8	29.66	20.4	231.9	17.[illegible]	92.96
XII.	12	4.03	2.8	29.66	20.3	228.5	17.[illegible]	93.90
Mean	..	....	...	.....	....	.....	17.[illegible]	93.61

The total heat expenditure by the engine can now be calculated. For the purpose of comparison of this pump with pumps of other types, it is convenient to reduce the heat expenditure to the equivalent expenditure of

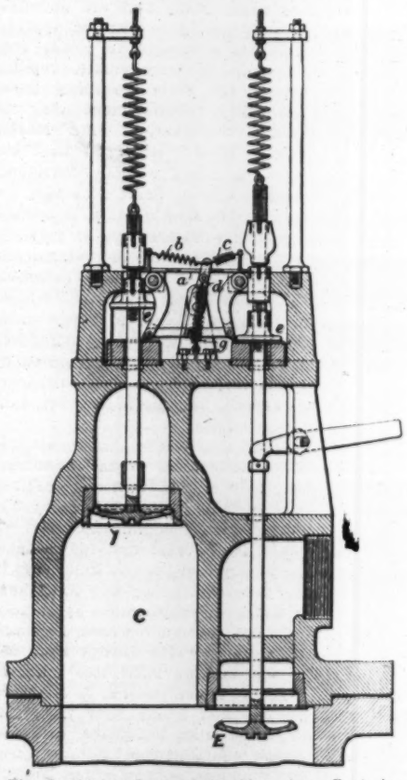


Fig. 3. Valve Gear of the Humphrey Explosion Pump.

standard anthracite coal. For the purpose of this reduction, it is assumed that anthracite coal has a calorific value of 14,400 B. T. U. per lb. Such coal used in a producer with an efficiency of 80% (calculated on the assumption that the steam remains uncondensed) would give a quantity of producer gas of a calorific value of 11,520 B. T. U. per lb. of coal expended. These results are shown in Table III.

TABLE III.—EQUIVALENT COAL CONSUMPTION, HUMPHREY PUMP.

Trial number.	Cu. ft. gas per P. HP.-hr.	B. T. U. per cu. ft.	B. T. U. expended per P. HP.-hr.	Lbs. anthracite per P. HP.-hr.
I.	82.62	146.48	12,105	1.051
II.	84.78	148.43	12,583	1.092
III.	83.76	146.06	12,232	1.062
IV.	82.38	145.49	11,985	1.040
V.	81.60	151.23	12,340	1.071
VI.	83.58	146.10	12,210	1.060
Mean.....	.....	.....	12,243	1.063
VII.	87.08	146.20	12,730	1.105
VIII.	93.24	139.82	13,036	1.132
IX.	92.46	144.33	13.344	1.158
Mean.....	.....	.....	13,037	1.132
X.	93.96	146.01	13.718	1.191
XI.	92.96	145.80	13,553	1.177
XII.	93.90	143.96	13,517	1.173
Mean.....	.....	.....	13,596	1.180

TABLE IV.—PRESSURES IN THE EXPLOSION CHAMBER.

Trial number.	Lbs. per sq. in — Average compression pressure.	Average explosion pressure.
I.	44.3	101
II.	45.5	102
III.	44.5	89
IV.	46	105
V.	45.7	100.7
VI.	42.3	102.7
Mean	44.7	100.1
VII.	33.7	85
VIII.	32	71
IX.	34	82.7
Mean	33.2	79.6
X.	18	87.5
XI.	20.3	86.3
XII.	21	85.3
Mean	19.8	86.4

Hence, if in a trial q cubic feet of Mond gas are used per hour per pump horse-power, the calorific value being c B. T. U. per cubic foot, the equivalent expenditure of anthracite coal in a producer would be

$$\frac{q \times c}{11{,}520} \text{ lbs. per P. HP.-hr.}$$

The pressures produced in the explosion chamber during compression and explosion, as shown in Table IV., are taken from indicator cards made during each trial.

GENERAL CONCLUSIONS.—The mechanism present in all other pumps, with its frictional waste of work, is absent. The absence of mechanism and attendant friction and wear, so that there is no need of lubrication except for the very small and light interlocking gear, must have the consequences that the apparatus is exceedingly durable, and the working expense extremely small. There can be no gradual loss of efficiency such as, in ordinary engines, arises from piston wear and consequent leakage. As all parts of the explosion chamber are washed by water every cycle, there is no possibility of pre-ignition troubles; also the temperature of all the metal is kept low by internal water cooling, and difficulty from expansion and contraction is eliminated. The maximum lift appears to depend solely on the length of the discharge pipe. The pump works at lower lifts automatically without any change and with no considerable change of efficiency.

It might seem likely that as the explosion takes place directly on the surface of the water, the water would be sensibly heated. This, however, is not the case; most of the heat generated disappears in the exhaust, and the part communicated to the water is quite small. In these trials the water was circulated round, being continually re-pumped; in the course of an hour the temperature in the storage tank did not rise 1° C.

The fuel economy is very striking, and, so far as I know, unequalled by any other pumping arrangement. The following is a summary of the gas and heat expenditure:

Lift, ft.	Pump horse-power.	Cu. ft. Mond gas per P. HP.-hr., at 760 mm., 0° C.	B. T. U. of gas per cu. ft.	B. T. U. expended per P. HP.-hr.	Lbs. anthracite in producer per P. HP.-hr.
32.87	16.15	83.12	147.3	12,243	1.063
25.95	12.32	90.93	143.5	13,037	1.132
20.73	10.99	93.61	145.3	13,596	1.180

An ordinary gas engine of three times this power, and using similar gas, would use at full load 72 to 84 cu. ft. per B. HP., and 95 to 100 cu. ft. at half load. If set to drive any form of pump, the gas consumption, reckoned on the pump horse-power, would be considerably greater. The Humphrey pump, when lifting water, works with about the same economy as a gas engine driving itself only.

Suppose a gas engine driving a centrifugal pump was required to do 16 P. HP. on a lift of 33 ft., or the same work as the Humphrey gas pump tested. On such a lift the efficiency of the centrifugal pump would certainly not exceed two-thirds, and might be rather less. Hence the gas engine would have to supply in normal working 25 B. HP. at the pump shaft. Gas engines will not work with an overload, and, to be safe, it would be desirable and usual to have a gas engine of 32 HP. maximum, which, in normal work, supposing the efficiency of the pump to be as assumed, would develop three-quarters of maximum power. So working, it would require 80 to 85 cu. ft. per hour of gas of the quality used in the preceding trials for each brake horse-power. Hence, it would require 1,920 to 2,040 cu. ft. per hour. The comparison stands thus therefore:

Gas engine and centrifugal pump, 120 to 127 cu. ft. of gas per P. HP.-hr.

Humphrey gas pump, 83.1 cu. ft. of gas per P. HP.-hr.

Working with less load the comparison would probably be more favorable to the Humphrey pump, because as the lift decreased, the efficiency of both the gas engine and the centrifugal pump would diminish.

Small steam pumps are notoriously inefficient and wasteful of fuel, and a comparison with them would be useless. But to show how remarkable the fuel economy of the Humphrey pump is it may be compared with large steam pumping engines of the highest class.

High-duty Worthington Engines.

	Compound, Nov., 1888.	Triple, Dec., 1896.	Triple, Feb., 1897.	Humphrey gas pump, Sept., 1909.
I. HP.	255.5	370.5	498.4	.....
P. HP.	217.1	320.3	449.8	16.15
Lift in feet.	53.7	92.3	129.1	32.9
Quantity pumped in gals. per min.	13,407	11,450	11,497	1,621
Coal per I. HP.hr.	1.696	1.402	1.530	.....
Coal per P. HP.-hr.	1.996	1.622	1.695	1.06

Some years ago I made careful and complete tests of a pair of compound and a pair of triple-expansion engines at the West Middlesex Water-Works. The engines were high-duty Worthington engines, of exceptionally low steam consumption, with boilers which gave a high evaporative efficiency with picked Welsh coal.

It was found that these fine steam engines, with the advantage of much greater lift, did not approach in economy the Humphrey gas pump. The compound engine required twice as much coal per pump horse-power as the Humphrey pump.

In the case of the compound steam engine the expenditure of heat in the boilers was 494 B. T. U. per min. per P. HP. The corresponding expenditure in a producer for the Humphrey gas pump would be 250 B. T. U.

Center Walks Supplemented by Back Alleys in Place of Roadways and Sidewalks in Venice, Cal.

By H. M. MEINELL.*

By common consent of its residents, centerwalks have superseded sidewalks in this picturesque city by the sea, 15 miles from Los Angeles.

The innovation practically converts the many short streets leading from the ocean front into recreation grounds, where children may play in safety without fear of being dispersed or injured by passing vehicles. By mutual agreement between the property owners and the city officials, all vehicular traffic is excluded from certain streets, the tradesmen and others being relegated to the use of 20-ft. alleys which abut upon the rear of all lots fronting upon the cross streets.

Seemingly there is no warrant in law for the usage, as the streets have not been dedicated for park purposes, but the unanimous public opinion of the community has brought about the custom which bids fair to be adopted by other seaside towns bordering upon the Pacific coast.

The accompanying illustration gives a glimpse of Park Ave., Venice, looking toward the ocean. The street is one of 80 and more which have been improved at the expense of the abutting property owners with the centerwalk system, as shown.

From houseline to houseline, the "street" is 40 ft. in width, extending 350 ft. at right angles with the ocean. The walk down the center varies, according to the choice of property owners, from 10 to 15 ft. in width. It is laid strictly according to specifications, recommended by the city engineer, approved by the board of trustees and filed at the city hall.

The specifications call for 3½-in. concrete foundation, laid upon the sand composing the street. No joints are permitted, except where work is stopped from day to day, and at such points a reinforcement of chicken-wire must be laid, the full width of the walk, where the concrete work is renewed.

The specifications call for a continuous strip of chicken-wire netting reinforcement, 3 ft. wide, of not more than 3-in. mesh, on each side of the center line of the walk, midway between the middle and the outer edge.

On top of the concrete base is spread a ½-in. finishing coat, composed of equal parts of cement and sand. The surface is neatly marked off in squares, while moist, and coloring matter, usually red or slate gray, is added to give the finished walk any hue desired.

One detail of the specifications, which tends to guarantee good workmanship, is the direction that the contractor must stamp his name in letters not less than ¾-in. in height and ¼-in. deep in the pavement at least once in every 60 lin. ft. of the work.

In the pavement shown herewith, the contract figures for the walk were 12 cts. per sq. ft. for the pavement and 16 cts. per lin. ft. for the curbing. The latter, in most instances, is made a part of the walk, extending down into the sand on either hand for 6 or 8 ins., thus acting as an anchor for the whole.

With the exception of a few thoroughfares which connect with county roads in the interior, all of the streets bordering upon the waterfront in Venice have been paved with a centerwalk, built either of concrete or wood.

Freedom from the noise and bustle of passing vehicles, with the consequent clouds of dust familiar to some neighborhoods; the safety and comfort with which mother and the babies may enjoy the open air before their own door-steps, and the exceptional opportunity for ornamental effects offered by the exclusion of traffic and the conversion of the roadways into footways are distinctions that residents of Venice would now be loathe to forego and it is believed that this feature of municipal life in the seaside community adds, not a little, to its popularity.

CENTER WALK IN PLACE OF ROADWAY AND SIDEWALKS, PARK AVENUE, VENICE, CAL.

*Venice, Cal.

The Use of Feed-Water Heaters for Locomotives.

Within the past few years there has been a revival of attempts to utilize the waste heat of locomotives for heating their feed-water, thus effecting an economy in fuel consumption. There are, of course, practical difficulties, as noted in our editorial columns, and in some cases these include additional weight and complication of apparatus. There are possibilities of material net advantages, however, so that experimental work along this line is carried on from time to time. We have made enquiry recently as to the later developments in the direction of feed-water heating for locomotives, and particulars of systems now in use are given below. In some cases only the exhaust steam from the brake pump is thus used, while in others a portion of the exhaust steam from the cylinders is used also, and in still other cases there is an auxiliary heater utilizing some of the waste heat of the smokebox gases. In one system, also, the live steam is used during the time when the throttle is closed.

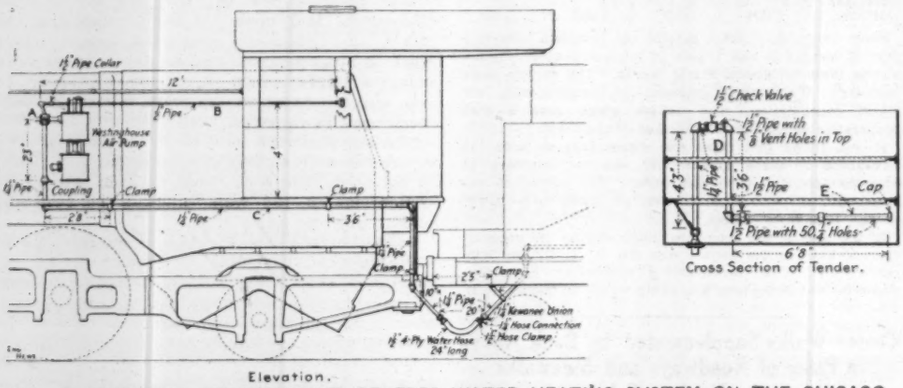


FIG. 1. STANDARD ARRANGEMENT OF FEED-WATER HEATING SYSTEM ON THE CHICAGO, BURLINGTON & QUINCY RY.

CHICAGO, BURLINGTON & QUINCY RY.—This road is notable as having adopted feed-water heating as standard practice, this applying to all engines in both freight and passenger service. A majority of the engines are equipped already, and the others are being equipped as they go into the shops for repairs. The method used is the delivery of the exhaust steam from the brake pump into the tender tank. Mr. C. B. Young, Mechanical Engineer, states that this system has been in use for a number of years, and is generally acknowledged as giving good results.

The arrangement of the apparatus is shown in Fig. 1. A valve (A) on the exhaust pipe of the steam cylinder (of the air brake pump) and operated from the cab by the rod (B), enables the exhaust to be turned into a 1¼-in. pipe (C) which is led back to the bottom of the tender tank. In the tank is a vertical inverted U-pipe (D), one leg of which is connected to the pipe from the engine, while to the other is connected a transverse horizontal pipe (E), this pipe being perforated for the escape of the steam.

It is stated that for every increase of 10° F. in the temperature of the feed water, there is a saving of 1° in the fuel consumption. Ordinarily, it is considered quite safe to raise the temperature of the water to 100° or 110° F., as injectors now on the market will handle water at a very much higher temperature than was practicable formerly, and there is very little trouble in this respect. Higher temperatures than those noted are used with some other heater systems. The principal trouble in practice on this road is due to the fact that the enginemen are rather slow to give their engines the advantage of the system, being afraid of getting the water too hot, so that the injectors will not handle it and the engine will be "killed" for lack of water.

CENTRAL OF GEORGIA RY.—A feed-water heating system designed by Mr. F. F. Gaines, Superintendent of Motive Power, has been in use for about 18 months on a freight locomotive of the 2:8:0 class. Mr. Gaines informs us that the results obtained have been so satisfactory that it is being applied to engines of three other types for further experiment, and it is expected that these will show substantially the same economy as the first engine. In this system, a feed pump is employed to handle the hot water, which is heated by utilizing the exhaust steam from the brake pump and feed pump, and a portion of the exhaust from the cylinders. The heating apparatus consists of two horizontal drums under the running-boards, and a pipe coil in the smokebox. The general arrangement is shown in Fig. 2.

The drums, Fig. 3, are 6 ft. long, each containing 29 tubes of 1¼ ins. diameter and 5 ft. 5 ins. long over the tube plates. The exhaust steam is admitted at one end and passes through the tubes, and the water of condensation is delivered to the tender tank, raising the temperature in the tank to about 174°. The feed-water circulating through the drum passes to the header of the 1¼-in. tubes in the smokebox, which are curved to lie against the shell, and over which the hot gases are directed by a deflector. On each side of the smokebox there are 75 tubes, fitted to headers 36 × 13 ins., and the two bottom headers are connected by a cross pipe. The total length of travel through these tubes is about 25 ft. The water is delivered to the boiler at a temperature of 190° to 200° F., according to the rate at which the engine is working.

The feed pump is of the ordinary duplex horizontal type as used for stationary boilers, and is mounted on the left side of the boiler (or beneath it in some cases). It has a 3-in. suction pipe from a three-way valve at the connection to the tender hose coupling, and a 2½-in. delivery pipe to the left-hand drum, which is connected to the other by a 2½-in. pipe under the boiler. A pipe of the same size leads from the right-hand drum to the top right-hand header in the smokebox, while another leads from the top left-hand header to the injection check valve. Thus the water passes from the feed-pump to both heater drums in succession, then through both sections of the heater in the smokebox, and finally to the boiler. The engine is equipped with two injectors also, their suction pipes leading to the three-way valve at the tender connection.

From the results of service performance and of road tests it is considered that the engine will show an economy of about 15% in fuel over ordinary engines of the same class. The accompanying table gives the results of road tests made in January, 1909, between Columbus and Macon, Ga., 100 miles. The tests included four engines, all of the same class; two were ordinary engines, one had the feed-water heater equipment, and one had a superheater of the smokebox type. This last was built for 160 lbs. pressure; the others carried 200 lbs. One of the ordinary engines had a narrow firebox and brick arch; all the others had wide fireboxes. The water used on this division has a low content of incrusting solids.

We are informed by Mr. Gaines that in making these tests it was desired to eliminate all elements of uncertainty, such as resistance of cars in various trains, and therefore a solid train of 50-ton steel cars, loaded with coal, was used throughout the tests, the same train being used in every run. In a preliminary test made on another division it was found that the results approximated very closely to the figures given in these tests, so that it is believed that the economy shown by the use of the feed-water heater is actual and can be obtained from day to day in regular service. Indeed, it is believed that both the engine with the feed-water heater and the one with the superheater would have shown about 10% higher economy if their boiler conditions had been equal with the other two engines. The two ordinary engines had new tubes which had been recently applied, while the engines with the feed-water heater and superheater had the original tubes which came in the engines from the builders. As these had been in service over a year, it is considered probable that they were

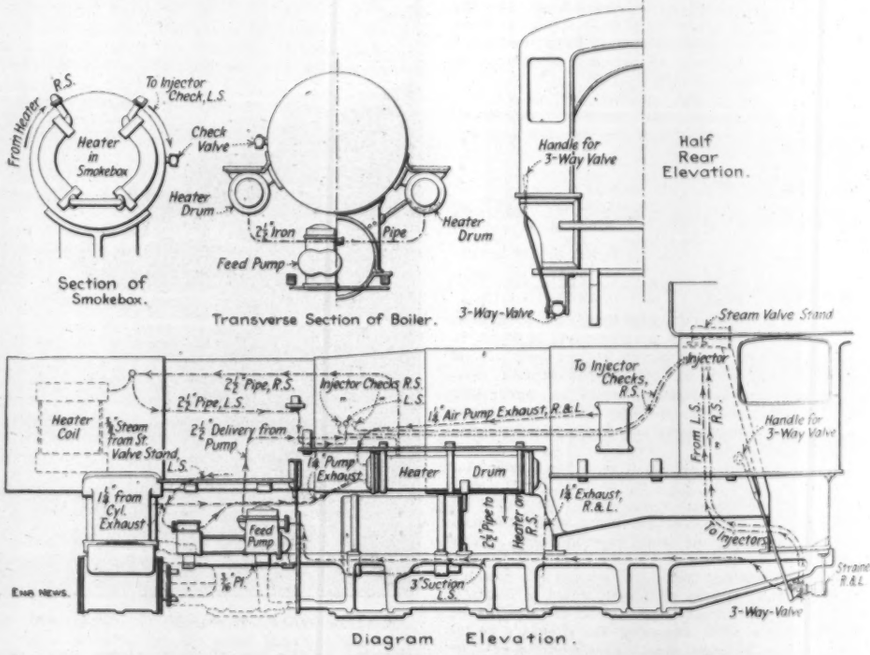


FIG. 2. FEED-WATER HEATING SYSTEM ON THE CENTRAL OF GEORGIA RY.
F. F. Gaines, Superintendent of Motive Power, Inventor.

pretty well coated with scale by the time of the test.

In making the tests the coal for the engine was put in 150-lb. sacks, so that a check on the amount of coal used was always obtainable. The tanks were calibrated for the water consumption. The engines used partly surface water and partly artesian water. There is a fair amount of incrusting matter in the water, and also ingredients containing a considerable amount of acids which cause pitting, resulting in trouble with the tubes leaking.

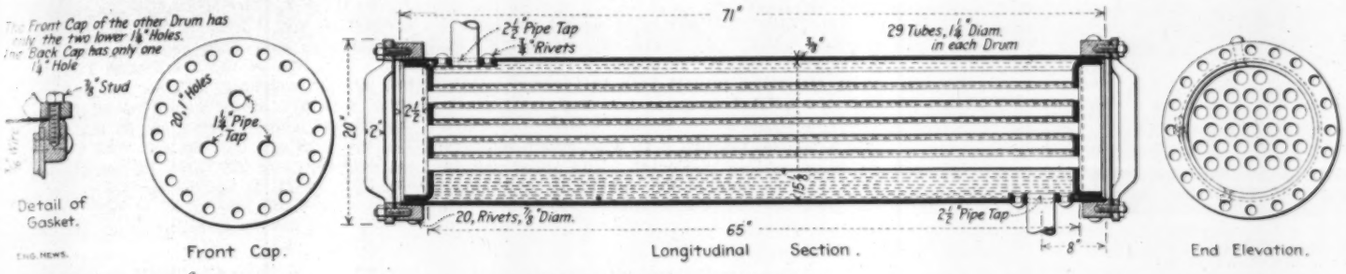
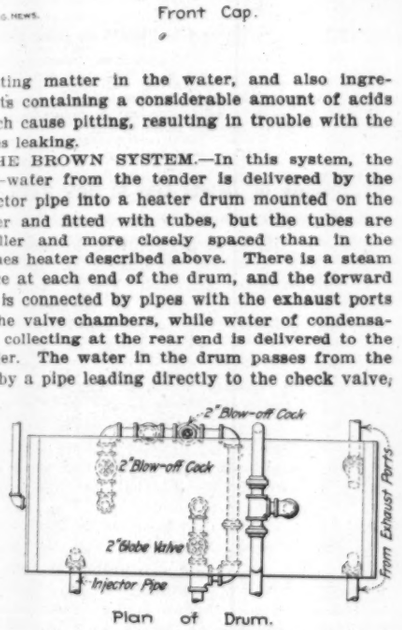


FIG. 3. FEED-WATER HEATING DRUM.

THE BROWN SYSTEM.—In this system, the feed-water from the tender is delivered by the injector pipe into a heater drum mounted on the boiler and fitted with tubes, but the tubes are smaller and more closely spaced than in the Gaines heater described above. There is a steam space at each end of the drum, and the forward end is connected by pipes with the exhaust ports of the valve chambers, while water of condensation collecting at the rear end is delivered to the tender. The water in the drum passes from the top by a pipe leading directly to the check valve, and is said to enter the boiler at a temperature of 200° to 212° F. This valve is on the right side of the boiler, and on the left is a similar valve supplied directly by an injector in the usual way.



There is a supplementary heater consisting of a tube coil in the smokebox, the purpose of which is to set up a gentle circulation through the drum and coil, causing sediment to be deposited and gas (which causes foaming) to be liberated. When the injector is working at full force there is no circulation, the pressure being equal at both ends of the coil. As fast as the water in the coil is converted into steam, it will pass out and unite with the water on its way from the top of the drum to the check valve, and the coil is fed by gravity.

This system is the invention of Mr. W. H. Brown, of the Brown's Feed-Water Heater Co., 510 Kasota Building, Minneapolis, Minn. It has been applied to two engines of the Chicago, Milwaukee & St. Paul Ry., and two engines of the Minneapolis & St. Louis Ry.

The arrangement of the drum and piping may be varied to suit the engine to which the system is applied, and Fig. 4 shows the equipment on an engine of the Chicago, Milwaukee & St. Paul Ry. The drum is 24 ins. diameter and 6 ft. long, with 269 tubes ¾-in. diameter and 5 ft. long, leaving a 5½-in. steam space at each end. The tubes of the smokebox section of the heater are 3 ins. diameter. The mud can be blown out as required by the use of the injector when on the road. The engine was used in a district having well water which contained a high proportion of incrusting solids, but it was operated for 19 months without any engine delays or failures. The boiler was then examined and found clean and free from mud. The smokebox coil was clean, and very little scale was found in the drum. With this device it is found practicable to mix artesian water and well water, which cannot be done otherwise owing to the liberation of gas in the boiler, which causes foaming. With the heater, the gas is liberated before the water enters the boiler.

We are informed that during the present year a comparison was made of the performance of two similar engines, one having the Brown

TABLE OF TESTS OF LOCOMOTIVES IN FREIGHT SERVICE; CENTRAL OF GEORGIA RY.

Locomotive No.	Special equipment	Boiler press. lbs.	Actual time of trip. h.m.	Stops No.	Stops Time h.m.	Coal consumed Total lbs.	Coal consumed Per 1,000 ton-miles, lbs.	Water consumed, lbs. Total lbs.	Water consumed, lbs. Per lb. of coal lbs.	Miles run per lb. of coal.
1223	Feed-water heater	200	7.01	9	1.09	10,200	99	71,158	6.98	19.6
1223	Feed-water heater	200	6.50	9	1.14	10,050	98	73,217	7.29	20.0
....	....	....	....	..	....	20,050	98	144,375	7.13	19.8
1224	Superheater	160	6.52	10	1.26	12,400	121	85,216	6.87	16.1
1224	Superheater	160	6.37	9	1.33	11,800	115	83,650	7.09	16.9
....	....	....	....	..	....	24,200	118	168,866	6.98	16.5
1222	None	200	6.56	12	1.21	10,950	117	85,283	7.11	16.7
1222	None	200	6.39	11	1.19	12,000	114	80,817	6.91	17.1
....	....	....	....	..	....	23,700	115	166,100	7.01	16.9
1081	None	200	6.50	8	0.42	10,950	106	77,042	7.04	18.3
1081	None	200	6.47	9	1.04	11,700	114	79,200	6.77	17.1
....	....	....	....	..	....	22,650	110	156,242	6.90	17.7

NOTE.—The train in each case consisted of the same 15 cars loaded with coal, and was handled by the same engineman and fireman. The weight of train in tons hauled one mile was 102,870 tons for each trip, or 205,740 tons for each round trip.

Engine No. 1081 has a narrow firebox and brick arch; the others have wide fireboxes. Engines Nos. 1223 and 1224 have the original tubes, supplied in 1907. Engines Nos. 1222 and 1081 have new tubes, applied by the railway company in November, 1908.

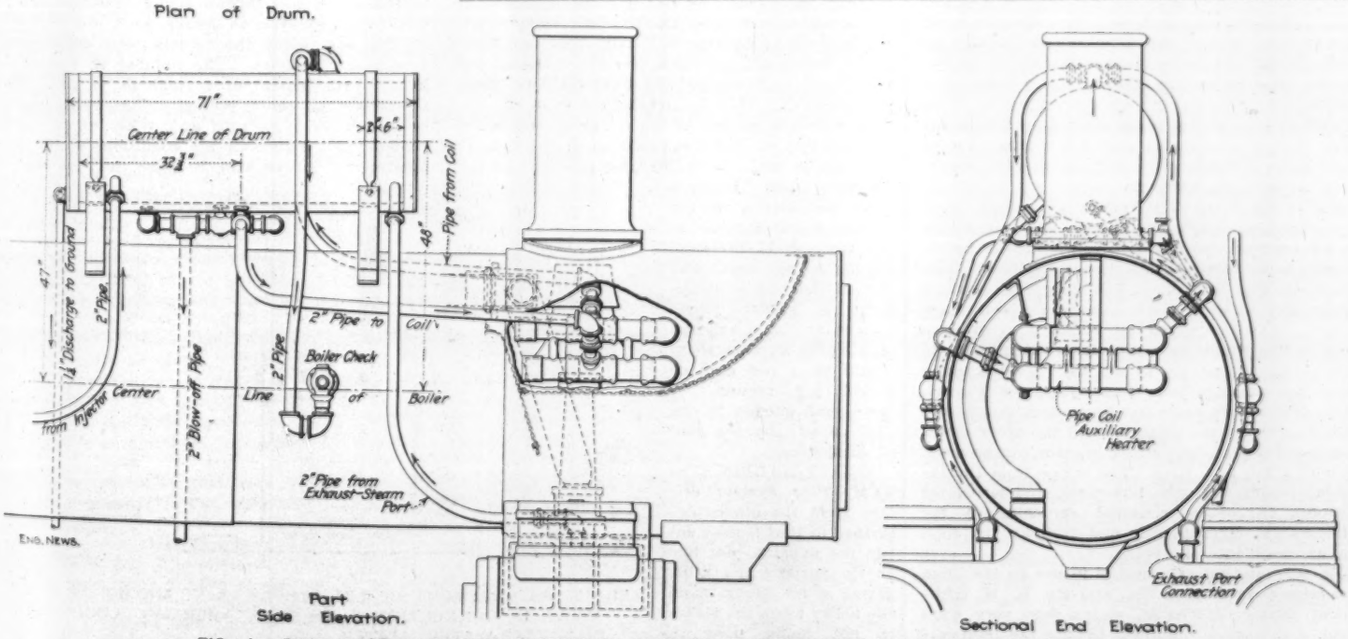


FIG. 4. FEED-WATER HEATING SYSTEM IN USE ON THE CHICAGO, MILWAUKEE & ST. PAUL RY.
Brown's Feed-Water Heater Co., Minneapolis, Minn.

heater and the other having no such device. It appears that with a greater mileage and heavier tonnage the engine fitted with the heater showed a coal consumption of 22.94 lbs. per 100 ton-miles, as against 29.95 lbs. for the other engine,

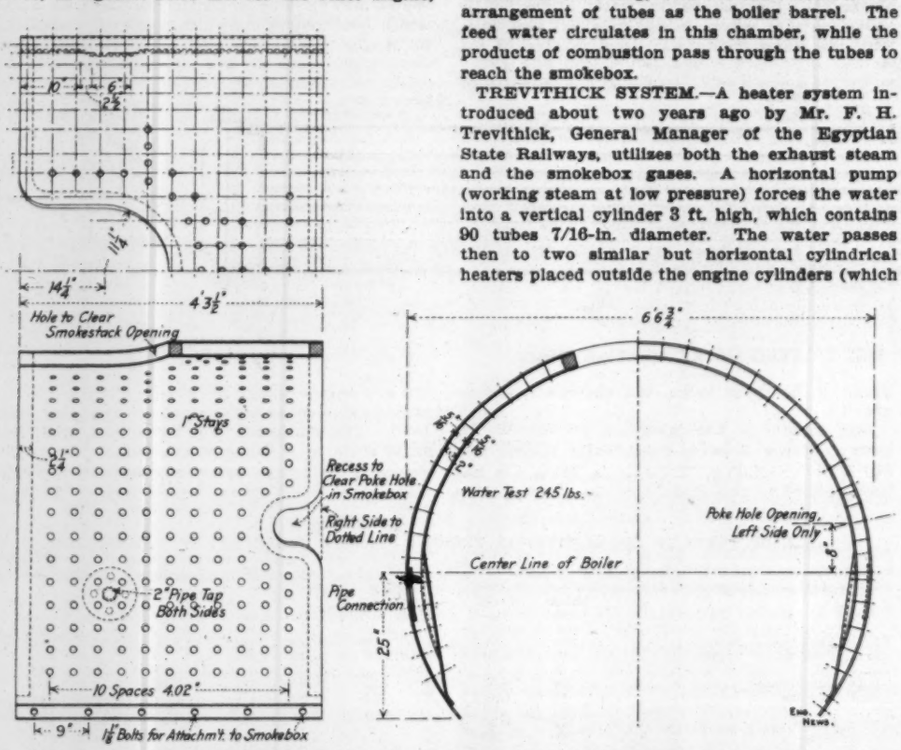


FIG. 5. FEED-WATER HEATER FOR SMOKE BOX; LAKE SUPERIOR & ISHPEMING RY. American Locomotive Co., New York; Builders.

or an economy of nearly 25% in favor of the heater system.

The results on the Minneapolis & St. Louis Ry. appear to have been less satisfactory, and Mr. John Tonge, Master Mechanic (who has recently resigned) stated that he did not think the claims made could be substantiated. On the other hand, the heater company has a letter from the Smoke Inspector of the Department of Health, at Minneapolis, advocating the use of the system as a means of reducing the smoke nuisance. This was based on a test made with a switching engine, and it was stated that when using heated feed-water a lighter fire could be carried, resulting in better combustion.

AMERICAN LOCOMOTIVE CO.—This company has equipped one engine with a device which consists of a flat shell or chamber of horseshoe shape fitted inside the smokebox. This chamber (Fig. 5) is about 4 ft. long, with a water space 2 ins. wide inside, the inner end outer plates being connected by staybolts. On each side of the engine is a pipe from an injector to the heater, but having in it a special valve which combines a line or pipe check with a boiler check (Fig. 6). Either valve can be opened, but in any case one closes the line pipe and the other closes the boiler pipe. Thus either injector can be used, but only one at a time. The water from the injector passes the open line-check and circulates through the heater chamber, returning by the pipe on the opposite side and through the open boiler check into the boiler.

The engine thus equipped is in use on the Lake Superior & Ishpeming Ry., and Mr. W. H. Richmond, Master Mechanic, states that very good results have been obtained, raising the temperature of the feed-water from 160° to 262° before it enters the boiler, and effecting a reduction in coal consumption. In addition to this, it was found practicable to increase the diameter of the exhaust nozzle to 5½ ins., the original diameter having been 4½ ins.

BALDWIN LOCOMOTIVE WORKS.—A feed-water heater which is an integral part of the boiler and not a separate attachment is a feature of the two immense Mallet duplex locomotives built recently for the Southern Pacific Ry., and illustrated in our issue of 1909. The main tubes end in a combustion chamber, beyond which is a chamber 5 ft. long, with the same number and arrangement of tubes as the boiler barrel. The feed water circulates in this chamber, while the products of combustion pass through the tubes to reach the smokebox.

TREVITHICK SYSTEM.—A heater system introduced about two years ago by Mr. F. H. Trevithick, General Manager of the Egyptian State Railways, utilizes both the exhaust steam and the smokebox gases. A horizontal pump (working steam at low pressure) forces the water into a vertical cylinder 3 ft. high, which contains 90 tubes 7/16-in. diameter. The water passes then to two similar but horizontal cylindrical heaters placed outside the engine cylinders (which are between the frames) and through which is passed a portion of the exhaust steam. From the third heater the water passes to a nest of 265 horizontal tubes 1 in. diameter and 18 ins. long, arranged in rings in the smokebox. With water leaving the tender at 68° F., the increase of temperature in leaving the four successive heaters is given as follows: 82°, 170°, 203° and 280°.

In a series of road tests, the coal consumption per ton of load handled was 10.45 lbs. with heaters in use and 13.30 lbs. when they were cut out. This shows a saving of 21.4%, or an increased consumption of 27.3% for coal when the heaters were not in use. With 300 trips per year on the 130-mile line between Cairo and Alexandria, the saving would amount to 300 tons, or $1,500 (coal costing $5 per ton). The cost of the heater equipment is $1,250, representing an annual charge of $187.50, so that there would be a net gain of $1,312 per annum, or more than enough in one year to pay for the cost of equipment.

DRUITT-HALPIN SYSTEM.—This system differs from the others described in that it does not use the exhaust, but has as its purpose the utilization of live steam from the boiler when the steam is not being used in the cylinders. Thus when the engine is standing or drifting, the steam is utilized to heat the feed water, being admitted directly into the heater drum or passed through a coil inside the drum. Where no coil is used, there are baffle plates in the drum, and the water flowing over these in a thin sheet meets the flow of live steam. The drum is about 3 x 12 ft., and is mounted on top of the boiler. Both injectors deliver water to the drum, a valve operated from the cab controlling the supply of the feed from the drum to the boiler.

This system is the invention of Mr. Druitt-Halpin, an English engineer, and has been in use for two or three years on some locomotives in England. In a paper read in July before the British Institution of Mechanical Engineers, Mr. George Hughes, Chief Mechanical Engineer of the Lancashire and Yorkshire Ry., stated that six tank engines have been equipped with the system. They are of the 2:4:2 class (with radial end axles), weighing 135,184 lbs. in working order, with 61% of the weight (or 82,462 lbs.) on the driving wheels, which are 68 ins. diameter. The cylinders are 18 x 26 ins. The boiler is 50 ins. diameter with 220 tubes 1¾ ins. diameter; it has 1,216 sq. ft. of heating surface (1,100 sq. ft. in the tubes) and 18¾ sq. ft. of grate area. The results were briefly summarized by Mr. Hughes as follows:

> Where stopping places are frequent on rising gradients there is distinct economy. Certain tests were carried out between Salford and Acrington, resulting in an actual saving of one ton of water, and under similar conditions elsewhere the saving was 12%. When, however, these engines have to take their turn on other sections of the line which are not so favorable the all-round economy is brought down to 4%.

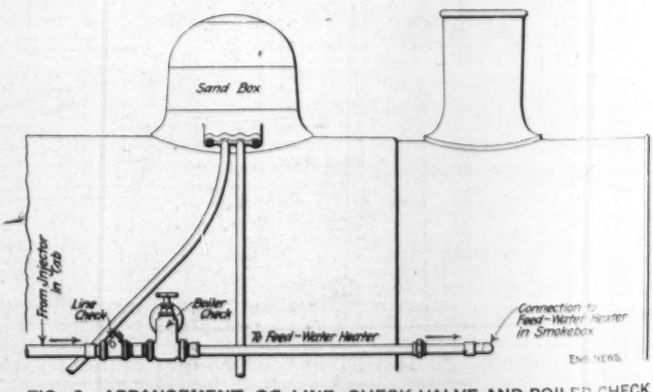


FIG. 6 ARRANGEMENT OF LINE CHECK VALVE AND BOILER CHECK VALVE IN CONNECTION WITH THE AMERICAN LOCOMOTIVE CO.'S FEED-WATER HEATER.

Explosions of Sewer Gas in New York City.

By A. A. BRENEMAN,* M. Sc., M. Am. Chem. Soc.

On the 7th of October, 1909, at 4.40 p. m., there was a violent explosion in the sewer at Forty-eighth St. and Tenth Ave., New York City. A number of manhole covers in the neighborhood were violently thrown up into the air, some going up 20 ft. A few seconds later, there was an explosion, considerably farther south in Tenth Ave., at a point not far from Forty-second St. Following this there was a series of explosions, some running continuously for distances along the avenue or the intersecting side streets, and some separated by considerable intervals of time and distance from preceding explosions. The area covered was, roughly, that bounded by Forty-second St., Fifty-second, Ninth Ave. and the Hudson River. The noise and concussion of these explosions were very impressive and the entire neighborhood was thrown into a condition of excitement, bordering on frenzy, as it was an hour of the day when the streets were filled with people and vehicles. The number of the manhole covers blown off is difficult to fix. The newspaper accounts represent statements made by a number of persons and, taken as a whole, should fairly represent the conditions of the explosion. It can be said, roughly, that the explosions affected an area of more than a half mile square and lifted probably over a hundred heavy iron covers weighing perhaps 100 lbs. each.

At the instant of the explosion, as described by observers, there was a burst of flame from each

*Expert Member, Municipal Explosives Commission, New York City. Consulting and Analytical Chemist, 97 Water St., New York City.

of the manholes in question, followed by a cloud of dense, black smoke, which spread in many places like a pall over the street. The force of the concussion broke innumerable windows and in some cases is said to have thrown pedestrians to the ground. It is a marvel, under these conditions, that there was no loss of life. About a dozen persons were injured, some of them quite seriously, and many narrow escapes from death are recorded. A peculiarity of the explosion was the fact that explosions took place at times in rapid succession, at points far removed from one another.

On account of the severity of the trouble and the ignorance of causes and of liability for repetitions of the explosions, prompt investigation was started. As to the source and cause of the explosions, there are two elements to consider, namely, the explosive material and the source of its ignition. It must have been a mixture of some combustible gas or vapor with the air, as such mixtures are known to be highly explosive when ignited, and the conditions of the explosion preclude consideration of any other materials. There are only two apparent sources of such materials of characteristics meeting the condition. These are illuminating gas and the vapor of the lighter petroleum oils. The sewers lie uniformly at a depth of about 13 ft. from the surface of the street following generally the grade of the street. They vary from 18 ins. to 5 ft. in diameter. Some, like that in Forty-second St., reach 12 ft. in diameter. The grade is sufficient to make a rather rapid flow of water through most of this area and, except in times of storm, the depth of water in the sewer is probably not more than one-sixth of its diameter on an average. The sewers discharge either directly into the Hudson River, as in the case of the large connecting sewers in Forty-second and Fifty-first Sts., or into these main sewers by means of the avenues in the case of the side streets, the sewers of which do not directly reach the river. The mouths of the sewers are covered to about half their depth at a mean low tide by the water of the river. They are therefore entirely closed by water during the greater part of the time.

ILLUMINATING GAS.—The city gas pipes are laid on an average within 3 ft. of the surface of the street. There is always considerable leakage from these pipes at the joints, and any freshly upturned earth in the street will give a characteristic odor. The soil under the streets is therefore more or less saturated with illuminating gas, and when the street is covered by a continuous sheet of asphalt or of stone sidewalk, there are but few openings for the escape of this gas from the soil. The street is pierced by small tunnels immediately below the surface, one class carrying the contact rails for the surface cars, and the other class carrying closed conduits for electric cables, or wires. When the electric-wire conduits were first introduced there were many manhole explosions which were correctly ascribed to accumulations of gas escaping from the soil into these conduits, and the explosion of mixtures of air and gas by sparks from the wires in the conduits. The street-car "trolley" tunnels are generally structures with concrete walls and offer comparatively few entrances for gas in the soil, while the open slot and the moving contact-plow assist continual ventilation. There is little to fear from explosions from these surface tunnels at present. The trolley tunnels, however, receive considerable mud and water from the streets through the slot, and these drain to a sump in the center of each block, from which sump they pass through a trap to the deep sewer below the street. The sewer is so deep that there is relatively little danger of the escape of illuminating gas from gas mains into it. Illuminating gas has a weight less than two-thirds that of air and tends to rise from the soil instead of penetrating deeply into it. The soil being denser in its lower layers, would also resist such downward diffusion of this gas. On the whole, therefore, the conditions seem to be decidedly against the accumulations of illuminating gas in the sewers. It should be added that the gas works are all located near the river, and their waste, whatever it may be, is discharged through sewer systems, not connected with the city system, directly into the river.

VAPORS OF VOLATILE LIQUIDS.—The use of volatile liquids in the trades was comparatively limited until the appearance of motor vehicles. Cleaning establishments and factories discharged very little of such volatile liquids into the sewers, and the quantity seems never to have caused sewer explosions. At present, in the region adjacent to the explosion area above defined, there are innumerable automobile garages, each of them having somewhere upon its premises a tank containing gasoline or a similar liquid. The storage of these liquids is regulated by existing laws, and with proper care and diligent inspection there is little to fear even from the large accumulation which the garage industry makes necessary. Unfortunately, however, gasoline is used extensively in washing machinery about the vehicles and for dissolving heavy oils that adhere to them. It is used also for washing the hands of thousands of employees from accumulations of grease, and it is used wherever heavy oils have to be removed from floors or other parts of the building. Impure gasoline, carrying these heavy oils, is hard to dispose of. If it were systematically collected and redistilled, the gasoline could be recovered; but the care and labor required to do this, and the relatively small return from oils so recovered, tend to discourage such economy. It escapes, therefore, too generally to the common sewer in the street. The sewers are always warmer than the air above the streets. In many cases they are made very warm through the escape of steam or hot water from factories. With volatile oils in the sewer, we have, therefore, the conditions for their ready conversion into vapor. The gasoline vapors arise and mix with the air, while the heavy oils are carried finally into the river, or, when the mouth of the sewer is closed, they gather at the water level within the sewer at some distance from the river, to be discharged only at low tide. Knowing that a mixture of gasoline vapor and air in certain proportions is highly explosive when ignited, and knowing that the range of proportion between the limits representing, respectively, too much and too little air to form an explosive mixture, is a very wide one, it will be seen that conditions for a sewer explosion may very frequently occur.

Such a mixture is harmless, unless ignited, and apart from one constant source, of which the writer will speak later, the conditions of ignition are not common. The dropping of a lighted match into one of the holes of a manhole cover, the dropping of blazing liquids into the sewer, or the very rare case of a culvert at a street corner being so imperfectly trapped as to permit ignition of sewer gas from the street, are possibilities. There are no other such causes probable.

There remains, however, the surface-car "trolley" tunnel, and here sparks are formed continually as a car passes along. The trolley tunnel has its connections with the sewer trapped by a water seal, but if one of these many traps is defective, being dry, so that the seal is broken, or having a broken pipe, there will be an airway between the trolley tunnel and the deep sewer beneath. The vapor of gasoline is over three times as heavy as air, and it does not rise rapidly into air nor mix with it. But in course of time, especially if aided by heat, it will penetrate into the air in spite of its greater weight and will make an explosive mixture. Assume that, through some cause, a single explosion has occurred by ignition of the gases in the sewer, causing a wave of pressure to travel through the sewer. The weakest points are the light manhole plates which close the openings in every block, and these are blown off. Suppose that the first explosion was local; that is, that only within a given length of sewer was there a quantity of explosive mixture ready to ignite. For want of fuel, the flame will be extinguished. The wave of pressure, however, may not have been entirely relieved by the opening of the manholes, and will be propagated to great distances along all the sewers connected with the first. The relief of pressure by the opening of the manhole in the sewer explosion may have left too little pressure to effect further opening of the manholes, as the wave of pressure moves along. Suppose, however, that at some distance from the first explosion, this wave of pressure again meets an explosive mixture of vapor and air, the tendency of this mixture will be to escape from the sewer at any opening. It certainly would be forced out of a defective trap into the street railway tunnel, and the excess pressure in the sewer might even be enough to blow out the water seal in a sound trap. If a car happened to be passing at the time there probably would be an explosion, repeating the conditions of the first. There is here, then, means of successive ignition and so of successive explosions, at points distant from each other, but all depending ultimately upon the original explosion. It is not necessary, therefore, that flame be carried continuously from the seat of one explosion to another, throughout a system of sewers. The essential conditions are the combustible mixture of vapor and gas and the coincidence of these with a more or less defective trap in the trolley tunnel, and with a passing car.

On October 14, one week after the severe explosions, the writer, accompanied by a sewer inspector and a gang of men furnished through the kindness of the Superintendent of the Bureau of Sewers and of the Chief Inspector of Sewers, inspected a number of sewer manholes covering the above district as they were opened. About a dozen openings were made, running roughly in a diagonal course from Fifty-seventh St. and Broadway to Forty-second St. and Tenth Ave. In all but one of these the odor of gasoline was detected. In many of them the water of the sewer carried floating oil. This was not necessarily gasoline, as that is rapidly converted into vapor.

If it be asked why sewer explosions are relatively infrequent while the causes of them seem to be always in operation, it can only be said that the necessity of coincidence of the proper conditions mentioned, with the somewhat rare opportunity for ignition of the original explosion, seems to be a sufficient explanation. Moreover, the operation of the laws, the care given in inspection of factories and sewers, the care of conscientious owners who would not necessarily incur such a danger, all tend to lessen the frequency of explosions. The consequences are so serious, however, that even these rare coincidences by which an explosion is brought about, should be made impossible.

In all cases the burst of flame from the manhole in these explosions was followed by dense black smoke. This indicates a volatile oil, and nothing else. Mixtures of illuminating gas and air produce no black smoke at all when they burn explosively. Mixtures of the vapor of volatile oils and air produce such smoke, practically without exception under sewer conditions.

It will be asked, finally, what remedy there is for the state of things described. The law forbids the throwing of gasoline into the sewer. The burden is upon the person who violates this law. It is no more incumbent upon municipal authorities to show how such violation of the law shall be avoided than it is to co-operate with a dynamite-maker for the keeping of his product away from the open street. It is a condition which every municipality must meet by that degree of stringency which may be required. Rigid inspection, including frequent chemical tests of sewer gases and liquids, rigid prosecution of offenders, the activity of inventors, and the increased caution of those who use and handle these liquids, will solve the problem. Special traps to prevent the entrance of gasoline into the sewers should be provided at every opening into the sewers by those who use gasoline, not as a relief from responsibility, but as a precaution against purely accidental escape of gasoline into the drains and so into the sewers.

Even with these traps, it is possible for gasoline, when agitated with water, and especially with soapy water, to remain suspended in a finely divided condition in water and to be carried along with it, so that it may be hours before

it has entirely escaped. A few drops of gasoline, shaken up in a bottle three-fourths filled with water and then floated out as far as possible by filling up the bottle with water, will yet have so impregnated the water with gasoline that, if the water be poured out to its original height, leaving a vacant space in the bottle, which is then closed with the cork, explosions may be obtained at the rate of two or three a day for two days in succession, when a lighted match is touched to the neck of the bottle at the moment when the cork is withdrawn. All of the material for these explosions has been suspended, finely divided and invisible, in the mass of the liquid. Water so impregnated, when it runs into the sewer, is another source of danger. The quantity of gasoline so taken, however, is relatively so small that probably it is only necessary to secure fairly good ventilation of the sewers to eliminate it as a source of danger.

A Novel Locomotive Rock Drill and a Remarkable Drilling Record.

By FRANK RICHARDS.*

Successive "new records" made in rock cutting operations are often not fairly comparable with either preceding or succeeding records elsewhere made, on account of the differences in the conditions under which they are made. Thus the rock-drilling record set forth in the following may not be properly comparable with performances in other cases of rock-drill work. But it is sufficiently striking and notable in itself, and may point the way toward more efficient methods of wide applicability.

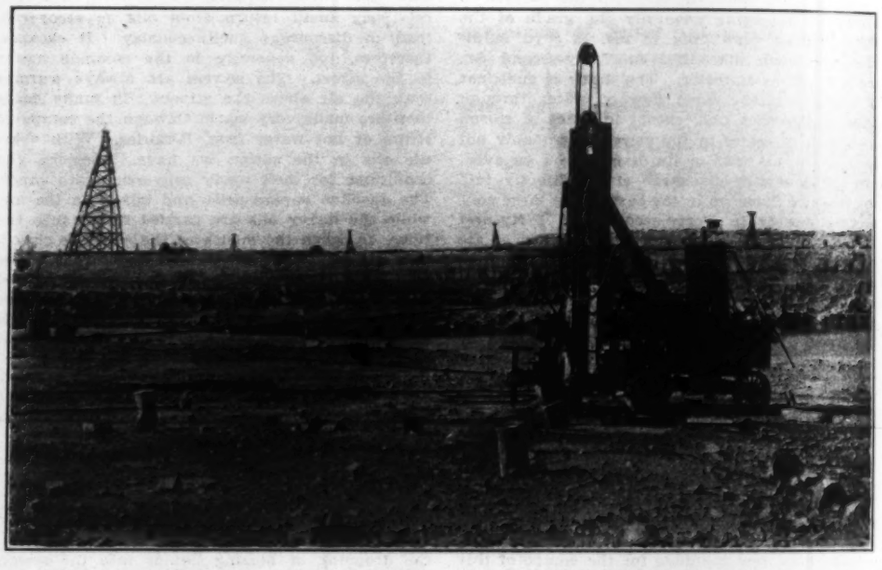
This record was made in the work of excavating the Livingstone Channel, a detail of the improvement of the Detroit River. Here was a straight channel to be cut in rock, 300 ft. wide, in the bottom of the river. The contractors for the section in question are Grant, Smith & Company & Locker; the work lies between Amherstburg, Ont., and Grosse Isle, Mich.

The area to be worked over was enclosed by cofferdams at each end, so that the operations were entirely "dry." The entire site was commanded by three Lidgerwood cable conveyors movable lengthwise of the channel as the work progressed; these conveyed all the material from the excavation and dumped it at a sufficient distance on either side. The overlying earth and loose stones were first removed by the aid of steam shovels, with which operation we at present have nothing to do, and then there remained a clear surface of rock to be excavated to a varying depth up to 12 ft. and over. The material is a soft lime rock running into dolomite, and is unusually free from seams, making it a comparatively easy proposition for the rock drill.

The drilling over the entire surface was all done in a single operation to the required bottom level. In commencing the drilling what might be called a standard equipment was employed, consisting of the usual type of rock drills, air operated, mounted on tripods and requiring two men for each. These drills were moved from hole to hole, usually a distance of about 8 ft., as required. These, of course, required a change of bit for every 2 ft. of depth of hole drilled, and a successive reduction of gage for each additional steel, so that to drill to a depth of 14 ft. and a bottom diameter of 3 ins., seven steels would be required with 3¾ or 3⅞ ins. for the starter. The actual average rate of the drills on this work was about 46 ft. of hole for an eight-hour shift. Four 3¼-in. Ingersoll-Rand drills were crowded all the time to keep one cable conveyor occupied.

The half-tone herewith shows the arrangement which has revolutionized all this. It is the invention of Mr. C. H. Locker, of the firm above referred to. It comprises in fact a single rock drill with a carriage and mounting and air-power devices which enable it to keep at work, actually drilling, as constantly as possible and *minimize the delays* required for shifting from hole to hole, for changing the steels, and for raising the drill by the feed screw when either change is made. This drill has largely made its record by avoiding stops, just as the big through express trains do. It has also the additional advantage of extra weight and power, which would not be practically available in a drill entirely operated and moved about by hand.

As seen in the half-tone, there is a horizontal frame built of heavy timbers and mounted upon four wide-tread wheels, those in front being on a fixed axle while those in the rear are swiveled for steering. There is a vertical air receiver or "air dryer," as they call it, on the rear of the platform and in front of this is a two-cylinder reversible hoisting engine which supplies the power for the several operations required. An extension of the shaft carries a small sprocket-wheel which connects by a chain to a larger sprocket driving the front carrying-wheel when the machine is to be moved. In front is a vertical heavily braced gallows-frame which carries the drill. When everything is in place the preponderance of weight is upon the front wheels, which is as it should be, and when the apparatus is in exact position for starting a hole the two jackscrews seen in front are set down solid upon the rock, taking most of the weight and holding everything rigidly in place. The manipulation of these jackscrews is the only hand operation involved when changes of position are made.



A LOCOMOTIVE ROCK-DRILL FOR DRILLING DEEP HOLES WITHOUT CHANGING STEEL.
(Designed by C. H. Locker.)

The drill used in this case is a 5-in. Ingersoll-Rand machine ("H2"). The first change made in it was to dispense with the usual shell or guide in which the drill cylinder travels up and down by the operation of the slow-acting feed screw. In place of the drill shell the front of this carriage provides vertical guides in which the drill cylinder fits as in its original shell, but with a travel of 10 ft. instead of 2 or 2½ ft. The drill is suspended by a wire cable of suitable size carried to the drum of the hoisting engine, one or two revolutions of which will raise the drill from the bottom to the top of the guides.

A single steel is used of sufficient length to take advantage of nearly the entire vertical travel of the drill cylinder. The feed is entirely by the suspended weight of the drill, a slow retrograde movement of the hoisting drum being accomplished by a worm gear arrangement which can be clutched in or out as required (as is also the fast speed for hoisting the drill and withdrawing the steel from the hole). Holes to a depth of 8 ft. can thus be drilled with a single steel without a stoppage, and the loss of gage in the operation is in this rock scarcely noticeable. For keeping the drill in place when starting there is a guide attached to the front of the machine and brought down quite close to the rock. This guide of course does not fit the steel but gives it a little liberty to dodge around, while still locating the beginning of the hole with sufficient accuracy. The front half of this guide is hinged and can be swung back out of the way when changing steels.

It is not necessary to describe this apparatus any more in detail. It is evidently a crude and, in a way, merely an experimental arrangement; even the air hoisting-engine was home-made. The machine is already being replaced by a carefully designed machine constructed entirely of steel and with additional provisions for economy and facility of operation. However, such as it is it has worked steadily for two or three months or more and made astonishing records.

The following figures are given by a responsible and careful observer. On Sept. 23, 1909, drilling 3-in. holes, 29 ft. of hole was drilled in 55 minutes. This included moving the drill four times, the time occupied in moving being about 45 seconds each. On another day the drill was timed for one hour. Handicapping the drill in this case was dull steel and low air pressure. Yet the first hole was drilled to a depth of 7 ft. 8 ins. in 7½ mins. The next hole was 6 ft. 6 ins. in 6½ mins., and at the end of the hour, with five moves, 37 ft. 3 ins. of holes had been drilled.

The following is from another observer: In 32 mins. it put down three holes, 6 ft. 2 ins., 7 ft. 2 ins. and 7 ft. 2 ins., and was moved three times, leaving it ready for the fourth hole, all in 32 mins. In this time there was a delay of 4 mins. caused by the driller neglecting to raise his bar and getting it bent.

The 6 ft. 2 in. hole in this case from start to finish took 5¼ mins. The time of moving, that is from when one hole was finished until another was started, was exactly 2 mins.

The performance of this machine is more strikingly expressed, however, by the following statement: Operated by two men, it took the place of the four tripod drills and eight men, and easily kept well ahead of the conveyor at all times. Its work compared with the tripod drill was approximately as *five to one*. The saving in air consumed has not been investigated.

On the new machine a reheater will be installed, and also a supplementary compressor to generate high-pressure air to follow the drill into the hole and blow out the dust.

*Managing Editor "Compressed Air," 11 Broadway, New York City.

RECLAMATION OF THE ZUIDER ZEE in Holland has been authorized by the States General. The work is to reclaim an area of 1,800 sq. mi. Its cost is estimated at about $80,000,000, and the time required is 32 yrs., according to the "Zeitschrift des Vereins Deutscher Ingenieure."

Paving Practice with Respect to Crowns of Roadway Pavements and Concrete Foundations.*

By GEORGE C. WARREN.†

The writer has read with much interest a paper recently presented to the American Society of Civil Engineers touching on the above subject, and perhaps some thoughts which come to his mind may be of interest.

At the outset, he begs to plead for a less frequent use of algebraic formulas to express simple engineering propositions, which could be more clearly stated in plain English. From the excellent paper above referred to, the following algebraic rule for computing street pavement surface curvatures is quoted:

The formula is:

$$Y = \frac{bx^2}{a^2}, \text{ in which } b \text{ is the depth of the gutter}$$

below the grade of the center of the roadway, a is the half roadway, x is the horizontal distance from the center of the roadway, and y is the vertical distance below the grade.

I believe that most of those of us who have sufficient technical education to be able from this formula to calculate the desired curvature of surface for any particular street will agree that a simple statement in plain English would be better understood by the average man if not by the technical engineer.

Given a roadway having a width of 60 ft. between curbs and a height of crown above gutter of 15 ins., the formula above quoted makes the grade at the quarter (point midway between crown and gutter) 3.75 ins. below the crown and 11.25 ins. above the gutter. How much more simple is the following plain English rule:

Make the crown ¼-in. above the gutter for each foot of width between curbs, and divide this crown into one-fourth between crown and quarter and three-fourths between quarter and curb.

The result of this rule would be: Width 60 ft. between curbs, divided by 4 = 15-in. crown, or 15-in. crown divided by 4 = 3.75 ins., level of quarter below crown, being exactly the same as the rather complicated algebraic formula quoted above.

As stated below, the writer is of the opinion that a better division of the fall is one-third from crown to quarter and two-thirds from quarter to curb, which, in the case of the above 15-in. crown, would provide a fall from crown to quarter of 5 ins., and from quarter to curb of 10 ins.

The following formula is quoted as employed by the late Andrew Rosewater, C. E., in his practice as engineer of the City of Omaha:

$$H = \frac{w\,(100\text{-}4\,P)}{5{,}000}$$

in which w is the width of the roadway, and P is the percentage of grade.

How much more simple is the reported formula of the engineer of the Chicago West Park Commission:

Make the crown 2% of the width of the roadway. [Of course meaning width between curbs.]

Mr. Rosewater's formula quoted above is the first published rule ever seen by the writer which recognizes the common-sense principle that the greater percentage of grade, the less should be the crown. In fact, the writer's observation is, that municipal engineers *very seldom* modify their crowns to meet the varying conditions of either steep grades; streets having car tracks or different pavement surfaces. With no allowance for car tracks, the prevailing custom provides a fall between track and curb—perhaps only half the width between curbs—the same as that planned for the same width of street without tracks. The result is that, as a general rule, the crowns on steep grades and on streets having car tracks are far too great for safety of horses or automobiles.

But is Mr. Rosewater's formula correct in the ratio of allowance for steep grades? With a roadway 40 ft. between curbs and of 2% grade, it would figure:

$$\frac{(100\text{-}4P) = 92 \times 40}{5{,}000} = .782\text{-ft.} = 9.18\text{-in. crown,}$$

which, in the writer's judgment, with classes of pavement providing the best foothold, is about correct.

With the same width and 6% grade, Mr. Rosewater's formula figures:

$$\frac{(100\text{-}4P) = 76 \times 40}{5{,}000} = .608\text{-ft.} = 7.3\text{-in. crown,}$$

which, in the writer's judgment, should not exceed 4 ins. with any kind of pavement on a roadway having 6% grade, 40 ft. width between curbs, and no railroad tracks.

Another important point. The writer has never seen in any published formulas, and far too seldom in practice, any recognition of the common-sense principle that some forms of pavement having smooth surfaces can stand and should have less crown than other forms of pavement providing better foothold.

Engineers, too, are frequently, if not almost as a general rule, prone to provide that the crown shall be the same level as the top of the curb, regardless of the width of roadway, or depth of gutter (exposed face of curb) required to properly carry the water to the catch basins, with the result that many wide streets have too little crown or too great exposed face of curb (if not both errors), for either appearance or utility. The writer believes that the general tendency of engineers is *to provide too flat crowns*. Water is the great enemy of all forms of pavement and unless the crown is sufficient to readily carry the water from slight depressions, which are necessarily to some extent in the surface of every pavement, the *durability of that pavement is very greatly reduced.*

There is no feature in pavement or roadway construction which should have more intelligent consideration of the engineer; and conversely, in the writer's experience, no feature which is given as little consideration to meet the conditions of each particular case as this matter of crown.

The following is a typical case of common error which has come to the writer's attention:

The width between curbs is about 45 ft. with double track. A portion is nearly flat, and about 700 ft. of the street has a continuous 8% grade. On the steep portion the top of the curb on the low side is about 8 ins. higher than on the high side. With only one cross street, about the middle of the steep portion, the engineer provided 9 ins. exposed face of curb to carry the water. On the flat portion he provided a desirable crown of say 6 ins., *but carried the same crown up the 8% grade.* The figures are from memory, but approximately correct, and illustrate the point. On the 8% grade, therefore, the cross section is about thus: (providing 14-in. crown on the low side in 14½ ft. width between track and curb).

With the sidewalk and curb grades previously established, this condition provided an unusually difficult problem, especially at the intersections on the steep grade, but by providing additional catch basins at intervals in the long steep grade, and 4-in. face of curb on the low side, and the track on the low side 2 ins. below the high side, it could have been very much improved. This would provide a 2-in. crown on the high side and 3 ins. on the low side. By raising the curb and walks 1 to 3 ins. on the low side the depth of suggested gutter could be increased to from 4 to 6 inches.

Objection may be raised to establishing track grade on one side 2 ins. lower than the track grade on the other side. The writer can see no practical objection but great advantage in safety to horses and automobiles by this provision, where the curb grade on one side of the street is necessarily lower than the curb on the other side. He believes that such objections as may be made are based on the novelty of such a provision and that on calm consideration it will be seen to provide both better appearance and superior utility to the undesirably high and unsafe crown which is otherwise necessary.

At the cross street, about the middle of the 700 ft. of 8% grade, the crown of the cross street was carried out to the track in the center of the street represented by the above cross sections, with the result that from the point midway between the curb and track on the low side and the pavement surface at the low corner curb, is a drop of about 24 ins. in 20 ft., just at the point where horses must travel and change their footing while turning the corner from a flat to a steep grade, while the hoofs on one side are about 3 ins. below the hoofs on the other side—a veritable horse trap,—and the *"pavement" not the "grade"* is publicly denounced as unsafe and slippery.

The writer has adopted and recommended with good satisfaction the following general rule:

For pavements having smooth surface, such as asphalt, creosoted blocks, and grouted stone blocks and brick, and having grade of two per cent. or less, with no car tracks, make the crown 1 in. to each 6 ft. width between curbs.

For pavements providing more secure foothold, such as stone blocks and brick, having bitumen filled joints; macadam or bitulithic, on streets having a 2% or less grade, make the crown 1 in. to each 4 ft. of width.

If street has car tracks, deduct the total width outside to outside of rails from the width between curbs and divide the difference (double width between track and curb) by six and four, respectively.

For grades between 2 and 4% provide one-half the crown provided by the above computation.

For grades above 4% provide a crown one-third that of the above computation.

Provide one-third of the lateral fall between the crown and the quarter and two-thirds between the quarter and the curb. By "Quarter" is meant the point midway between the center of the roadway and the curb or, in the case of car track streets, the point midway between the outside rails and the curb.

Some engineers have objected to such flat crowns on steep grades, because they do not rapidly carry water to the gutter. The answer is you cannot, in any event, on steep grades carry the water directly to the gutter, and it is better to let it run a little down the center of the street during the comparatively short periods of rainfall than to have the crown unsafe for horses at all times.

Now, to the other topic of the subject.

Concrete Foundations.

The writer of the article above referred to, after commenting on rolled stone pavement foundations if the subsoil is suitable, says of concrete:

As the concrete is generally from 6 to 8 ins. thick, and is spread over a large surface, and not deposited in bulk, as in walls, abutments, etc., it is necessary to take more than ordinary care to obtain good concrete. *A small sand pocket* may make little difference in a large mass of concrete, but *in a sheet like pavement it may be the cause of a large hole which will ruin the wearing surface and extend with great rapidity under traffic.*

The writer is a firm believer in rolled stone or bituminous foundation in cases where there is a sufficiently solid subsoil, such as gravel, stone, or gravelly clay, which can be rolled solid, but in his twenty-five year's practical experience he has never seen holes in otherwise good concrete foundation of a street pavement which could possibly be attributed to "a small sand pocket" in the concrete, and he cannot believe that such pockets exist in any well mixed concrete, whether machine or hand mixed.

As to thickness and proportions of cement used in concrete, the writer believes that fully one-third of the thickness of concrete frequently used is a wanton waste and that, aside from the thickness, about one-third of the cement usually specified is used unnecessarily.

As stated by the writer of the article herein referred to, "Concrete is generally from 6 to 8 ins. thick," although in the writer's [Mr. Warren—Ed.] experience more than 6 ins. is seldom specified. When he [Mr. Warren] says that in his judgment, *under ordinary conditions of well rolled sub-soil 4 ins. of first-class Portland cement concrete is as good for pavement foundation as 4 ft., provided the concrete is not disturbed after it is put in place until thoroughly set* he is aware that most engineers will, at first thought, controvert the statement, but he has many cases of practical experience to back his judgment and will cite one. In the year 1907, in Niagara Falls, N. Y., the company with which the writer is connected had a contract for laying bitulithic pavement on several streets aggregating about 30,000 sq. yds. The specifications provided for foundation of rolled, broken stone, poured with bitumen. On grading the street, a very weak clay subsoil and many recently-filled trenches developed, on account of which the city officials permitted a change to 4 ins. of Portland cement concrete. Before the surface was laid, or the concrete permitted to be otherwise disturbed, it had become *thoroughly set*, "as hard as a rock," and such that no wagon drawn by horses could break through it. The twelve-ton three-wheel road roller used in compressing the bituminous surface made no depression in the foundation. Two years later the writer examined the streets and found them to be in perfect condition, with the exception that two poorly-filled cross trenches had settled. As a whole, would 4 ft. of concrete have been practically any better than the 4 ins. used? But some engineers will say "4 ins. of concrete is not sufficient over poorly-filled trenches," to which the answer is, "neither is 6 ins., nor 8 ins.," and the remedy for such cases is properly back-fill your trenches, and, as an additional precaution, "provide an extra 6 ins., or even 1 ft. of concrete over and extending a few inches beyond the trench." In other words, "put your extra concrete where it is needed, i. e. over the trench, and don't, on account of the trenches, use several times as much extra concrete over the entire street, on probably nine-tenths of which it is not required." This matter of back-filling and reinforcing trenches is one that is very sadly neglected by both contractors and engineers generally.

PROPORTIONS OF CONCRETE INGREDIENTS—In the early days of concrete pavement foundation construction—say twenty-five years ago—it was the general custom to specify "uniform-sized stone passing —-in. ring, free from fine material," in the proportion of 1 part cement, 2 parts sand, if natural cement, and 3 parts sand if Portland cement, and 4 and 6 parts, respectively, of stone.

"Uniform-sized stone," as so specified, has about 40% voids, so that in 4 cu. ft. of stone there is 1.6 cu. ft. of voids to be filled. The cement is lost in the voids in the sands, so that 2 parts of stone to 1 part sand, as specified above, provides enough mortar to fill the voids in the stone and a surplus of about 25%, which was a safe proportion. Subsequently engineers came to generally accept the fact that it is a mistake to eliminate the fine particles of stone, and that a better concrete can be made by permitting the use of certain proportions of fine stone and a dense mineral aggregate uniformly regulated—say "run of the crusher," with the dust screen out, which yields about 25% voids. But as a rule, the

*A paper prepared for the convention of the American Society of Municipal Improvements, Little Rock, Ark., Nov. 9 to 11, 1909.

†President Warren Bros. Co., 50 Temple Place, Boston, Mass.

‡Oct. 6, 1909. See Proc. Am. Soc. C. E., Vol. XXXV., No. 6, August, 1909.

engineers stick to their old formula of 1-3-6, which with such a stone gives:

6 cu. ft. stone at 25% voids = 1.5 cu. ft. voids.

1 cu. ft. cement to 3 cu. ft. sand = 3.0 cu. ft. mortar, or twice the amount of mortar necessary to fill the voids. With such a stone, the proportions of 1-3-9 would provide ample cement and yield:

9 cu. ft. stone at 25% voids = 2.25 cu. ft. voids.

1 cu. ft. cement and 3 cu. ft. sand 3.0 cu. ft. mortar, or enough mortar to fill the voids and a surplus of 33⅓% *and fully* as strong concrete as the old 1:3:6 "uniform-sized stone" specifications. Hence the statement above that one-third the cement usually specified in pavement foundations is wasted. The writer believes that the time is not far distant when engineers generally will recognize that the true scientific and economical specification for concrete pavement foundation is one which provides uniform proportions of Portland cement and sand, or equivalent in crusher screenings (1 to 3) and will *require* that the stone slag or gravel of which the mineral aggregate is composed be so graded as to sizes that nine parts of stone will make a solid, dense concrete. In the writer's judgment, the best specification along this line which has been brought to his attention is the one adopted by the National Cement Users Association at its meeting in Cleveland in January, 1900, as follows:

SPECIFICATIONS FOR PROPORTIONING INGREDIENTS FOR PORTLAND CEMENT CONCRETE FOUNDATION FOR STREET PAVEMENTS.

FINE AGGREGATE shall consist of sand, crushed stone, gravel, or slag varying in size, passing when dry through a screen with openings ¼-in. in diameter; shall be of siliceous material, clean, coarse, free from vegetable loam or deleterious matter and not more than 6% shall pass a screen having 100 meshes per lin. in.

COARSE AGGREGATE shall consist of crushed stone, gravel, brick or slag which is retained on a screen having opening ¼-in. in diameter and pass through a screen having openings 3-in. in diameter; shall be clean, hard, durable and free from all deleterious materials.

MORTAR shall be made with fine aggregate as above specified, mixed with such proportion of cement as will over-fill the voids in the fine aggregate by at least 5% of such voids.

CONCRETE shall be made of coarse aggregate mixed with such proportion of mortar made as above specified in sufficient quantity to over-fill the voids in the coarse aggregate by at least 10%.

SURFACE.—In the case of brick or other form of block pavements, the surface of the concrete shall be as smooth as practicable. In the case of asphalt or bitulithic or other sheet pavement, the foundation shall be finished as rough as practicable in order that the plastic surface will as thoroughly as practicable unite with the concrete foundation and prevent slipping or separation between the concrete and the wearing surface.

In all cases the general contour of the surface of the concrete shall be as closely as practicable parallel to and the requisite depth below the surface of the completed pavement in accordance with the grades established, and the directions of the city engineer.

If any portion of the concrete when tested by a template or a straight edge 6 ft. in length shall show a surface more than ½-in. above or ½-in. below the grade established by the city engineer, then the high places in such concrete shall be picked or otherwise brought down to the proper grade and the low places shall be filled to the proper grade with fine concrete.

TEST FOR VOIDS.—To determine the voids in the "coarse aggregate" or "fine aggregate," prepare a vessel, the cubical contents of which is exactly 1 cu. ft. (1728 cu. ins.), being smaller at the top than at the bottom. Fill the vessel with the aggregate thoroughly dried "coarse" or "fine" as the case may be, which is to be used. Thoroughly shake or jar the vessel containing the aggregate until it is compacted as thoroughly as possible and the vessel is level full. Then ascertain the net weight of the fine aggregate in the vessel, deduct this weight from 166 (the weight of a 1 ft. cube of mineral of which the fine aggregate is composed) divide the difference thus obtained by 166. The result is the percentage of voids.

The advantage of this specification is that if either the fine or the coarse aggregate furnished is of uniform size, the contractor will be required to use enough cement to fill the then large proportion of voids in the fine aggregate and enough mortar to fill the then large percentage of voids in the coarse aggregate. On the other hand, if materials are available which will produce a smaller percentage of voids in either the fine aggregate or the coarse aggregate, the contractor can figure his proposal accordingly and the city get the benefit of the lower cost of construction.

POURED CONCRETE FOUNDATION.—A few words on this matter may be of interest. At the outset the writer wishes not to be understood as in any degree commending the system of grouting crushed stone and *rolling it after pouring and while the cement is setting* On the contrary, he believes that such a system is contrary to the sound, well-established engineering principle that concrete should be undisturbed as soon as possible after adding the water to the cement and should remain so undisturbed until the concrete is thoroughly set, and that the rolling of concrete is very bad practice which, to a greater or less extent, ruins the cement.

In the year 1908, the city of Wilmington, Del., under its efficient street commissioner, Frank W. Pierson, began laying concrete foundation for its pavements by:

(1) Spreading on the rolled subsoil 5 ins. of crushed stone passing 3-in. and remaining on 1½-in. ring.

(2) Rolling with 7-ton tandem steam roller, which left *a uniformly-graded but well-roughened surface to the base.*

(3) Pouring with grout made of 1 part cement and 3 parts sand, and sufficient water to provide the creamy consistency necessary for free pouring. The quantity of grout was such as to leave from ¼ to ½-in. of the angles of the stone particles protruding above the mortar.

(4) *Leaving the concrete absolutely alone* until the cement was thoroughly set—from one to two weeks, depending on weather conditions.

The result is very gratifying. The surface of the concrete, while having the desirable uniformly-surfaced grade, is sufficiently roughened to firmly "grip" into the bituminous surface to follow.

The concrete is *too firm to permit displacement by any wagon which can be driven over the completed pavement, and that is all that is desired.*

A sawed cross section of concrete shows that while the voids are not *thoroughly* filled, the mortar has extended to the bottom and every stone is firmly held in place by the mortar. When the writer was first consulted about this, before the work had begun, he was skeptical and feared the mortar would not flow sufficiently to the bottom to make a solid concrete, but "the proof of the pudding is in the eating" and the practical successful use, on a large scale, put his skepticism to naught. For a water-tight dam or bridge abutment, the result could hardly be considered "first-class concrete," but to sustain loads and provide a solid foundation which traffic cannot disturb for any form of street paving wearing surface it is practically as good as anything could be, and is "first-class concrete" for the purpose. Unfortunately the writer has not access to the costs of the Wilmington work, but that there is some saving in both cement and labor over mixed concrete of the same depth appears to be evident.

The Revised German Standard Specifications for Portland Cement.

During the past year the Verein Deutscher Portland zement-Fabrikanten, the German association of Portland cement manufacturers, has drawn up a new set of specifications for the testing and delivery of its product. In general this new set does not differ greatly from the old or from the familiar standards of this country, but in one or two details the difference is marked, such as, for instance, the substitution of a cube compression test for the old briquette tension test for strength. At the recent meeting at Copenhagen of the International Association for Testing Materials, Prof. M. Gary presented an abstract of the changes. From this report we have taken the important items.

The new standards differ from the old ones in two important particulars.

(1) The defining conception of Portland cement is supplemented; the chemical composition of the material is thereby taken into account.

(2) The testing for tensile strength is given up; in its place the requirements of the standard mortar in regard to compression and the degree of fineness of the grinding of the Portland cement are considerably increased. As the properly determining standard test, the compression test on cubes is introduced, which is to extend to bodies of material which have lain for one day exposed to the air, and six days under water and have been hardened by 21 days' exposure to the air. As a preliminary trial, the test of cubes after one-day hardening in moist air and six-day immersion in water is introduced.

While the conception of Portland cement defined in the old standards regards it as a product resulting from the burning of an intimately combined mixture composed of lime and argillaceous materials, as principal ingredients, till these form clinker, and the subsequent pulverization of the material to the fineness of flour, the chemical composition of the Portland cement is, in the new standards, set at not less than 1.7 parts by weight of the total of lime to 1 part by weight of the total of soluble silica + alumina + oxide of iron.

To this flour, when required for special purposes, additions of not more than 3% may be made. The proportion of magnesia may be 5% at most, and that of sulphuric acid anhydride must not exceed 2½%.

These decisions remove all doubts as to whether certain cement mixtures may be termed Portland cements or not. On the basis of careful experiments lasting for years, the upper limit for the proportion of magnesia has been fixed at 5%, after it has been established that up to this amount the material cannot produce disintegration in the clinkered Portland cement. In the same way it has been determined by careful experiment, that 2½% of anhydride of sulphuric acid may be allowed to pass unchallenged, without disintegration being produced. After specially searching experiments, it has been established beyond doubt that cements with very low percentages of sulphuric acid do not deserve any sort of preference over others in which the percentage of sulphuric acid approaches the higher limit.

It being a matter of experience, that it is not possible to draw conclusions from strength results obtained with Portland cements without sand admixture the testing of Portland cement in the mixture with the old well-tried standard sand from Freienwalde is retained, and, since in use the mortar is in the first line subjected to a compressive strain, and the compression strength can be determined with the greatest degree of reliability, the compression tests alone are to be decisive.

From the results of the numerous comparative tests it has been established that the reliability of the compression test is considerably greater than that of the tensile test. For a decisive test, however, only the most reliable tests that can be made should be permitted—tests that offer guarantee that, with careful work, concordant results will be obtained even in different places. In view of the reliability thus to be desired, the use of plastically molded samples, such as have been recommended in several quarters, has been decided against. The old ramming method, with the Böhme hammer, which has for years proved satisfactory in Germany, has been retained.

According to the new standards, Portland cement is to be ground so finely, that it only leaves a residue of 5% on a sieve of 900 meshes to the sq cm. (a 76-mesh in the inch standard). The width of mesh of the sieve is to be 0.222 mm. (0.0087 in.).

Slow setting Portland cement with 3 parts by weight of standard sand to one of cement shall, after 7 days' hardening, 1 day in moist air and 6 days under water, attain a compressive strength of at least 120 kg. per sq. cm. (1,710 lbs. per sq. in.); after a further hardening for 21 days in air of 15°—30° C., the compressive strength must be at least 250 kg. per sq. cm. (3,560 lbs. per sq. in.). In cases of contention only the test after 28 days is to be applied.

Portland cement that is intended for hydraulic engineering structures shall, after 28 days' hardening, 1 day in moist air and 27 days under water, show a compressive strength of at least 200 kg. per sq. cm. (2,850 lbs. per sq. in.)

In the case of quick-setting Portland cements, the strength after 28 days is, in general, less than that given above. When, therefore, strength values are quoted, the time of setting is always to be mentioned as well.

It was a matter of conviction, that, especially for the comparisen of several cements with one another, the test with a high proportion of sand was absolutely necessary; as a standard proportion, 3 parts by weight of sand to 1 part cement was adopted. When, however, the useful work to be obtained from a Portland cement is to be determined, series of tests with a higher proportion of sand were recommended.

The testing method agreed upon on the so-called combined hardening method (1 day air, 6 days water, 21 days air) is accommodated to the conditions of everyday practice, since by far the largest proportion of Portland cement is used for building purposes. This system of testing was taken up as the outcome of many thousands of tests and it was established by means of curves of frequency of the new and old water-hardening methods, that either could be used with equally reliable results. All endeavors to discover a reliable method of testing for pure air-hardening have proved fruitless. It has become apparent, that warmth and moisture of the air and other local peculiarities influence the test results obtained by air-hardening to such a degree that concordant values at different places cannot be obtained. The old Prussian standards came into force on July 28, 1887. They have served the German Portland cement industry as a guide for more than 20 years, and have been imitated in many civilized countries. It is to be expected that the new standards will perform their part in a still higher degree than the old ones in promoting the development of the industry and it would be in a high degree desirable, that other countries should join in the advance made by the German industry and make the highest possible requirements on the reliability of the testing methods.

AN AIR-COMPRESSOR DRIVEN BY A GASOLINE engine has just been put on the market by the Chicago Pneumatic Tool Co. The gas and air cylinders are placed tandem and the air inlet-valves are operated mechanically so that the compressor can run at high speed. Cylinder head joints are avoided by casting the head and half the cylinder barrel in one piece, thus making but one joint necessary midway in the cylinder length. The gas-cylinder is of the valveless two-cycle type and can use either gas or gasoline as fuel. The machine is built in three sizes of 15, 22 and 30 HP. and with capacity of 70 ft., 105 ft. and 150 ft. of air, respectively. The fuel consumption is said to be about 1¼ pints of gasoline per horse-power-hour. The machines are built either for stationary service or for mounting on a truck to make a portable outfit.

THE CAYUGA AND SENECA CANAL project, submitted to the referendum ballot of the citizens of New York State at this year's election, was carried by a majority of about 15,000 votes, according to the reports of the Barge Canal Agitation Committee.

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With this issue of Engineering News we begin the publication of a new department which we hope will be of great usefulness to both engineers and contractors. The department is really an extension of the work which has been carried on by us in a limited way for many years, of publishing the current prices of materials generally used in engineering work. These prices will be published in the first issue of each month, and a special effort will be made to have them complete, accurate and authoritative. It is not deemed necessary, for the purposes of most engineers and contractors, to publish these prices every week. The changes in market prices during a month are not commonly so great as to affect materially the accuracy of an engineer's or contractor's estimate. It is believed, therefore, that it is better to make a complete publication, covering all engineering materials, once every month, than to take the space necessary for a weekly publication.

We wish especially to solicit for this department the active cooperation of our readers, both those engaged as engineers and those in contract work. To a very large degree, the success of Engineering News has been due in the past to the cooperation of the profession with its publishers. In this especial matter of current market prices, every engineer and contractor appreciates the importance of having at hand accurate and reliable quotations of the materials which are made use of in carrying out all engineering works. But the best possible basis for quotations is the prices actually made, from day to day and week to week, by actual buyers and sellers. If engineers and contractors in various parts of the country will take the pains to inform us as to the prices they are able to obtain in current contracts for materials, it will be of very valuable aid to us in checking the information which we collect from other sources.

We wish to emphasize this idea even further. The services of the engineer of the present day are valued by his clients in pretty close proportion to the extent to which he can furnish accurate guidance in a business way. If the business man can go to his engineering adviser and receive an estimate on the cost of a piece of work, with full confidence that that estimate will be accurate and reliable, he will be more ready to employ the engineer and more willing to pay him liberally for his services. Now, how shall the engineer post himself accurately as to the cost of work to be carried out? The individual engineer cannot evolve knowledge as to prices and costs from his inner consciousness, or from any mathematical or physical theory. Prices and costs are matters of fact and experience. But, while the individual engineer is helpless in this matter, engineers acting in conjunction with each other can obtain just the information that will be of greatest value to them in their work. Engineering News offers itself as the medium by which this cooperation among engineers and contractors can be effected. A general response to this appeal will enable us to furnish to our subscribers, in the first issue of each month, the most accurate and reliable price list of engineering materials that has ever been published anywhere. We may add that all such information so furnished will be considered confidential, unless express permission is given for publication, and suitable acknowledgment will be made.

The recent New Orleans deep waterway convention in the formal resolutions which it adopted:

> accepted and indorsed those portions of a recent report by a special board of survey composed of United States engineers which demonstrate the complete practicability of the Lakes to the Gulf deep waterway, but repudiated and condemned that portion of the report declaring against the commercial expediency of and necessity for the project.

It must be a very peculiar mind which could find in the Board of Engineers' report any "demonstration of the complete practicability of the Lakes to the Gulf deep waterway." As for the "condemnation" of the Board of Engineers because it inquired into the commercial need of a 14-ft. channel, the truth is that the Board *did just what Congress ordered it to do.* If the plain facts which the Board presented were unfavorable to the 14-ft. scheme, "repudiating and condemning" will not alter these facts.

We commend to the deep waterway promoters who do not like to accept the statements and opinions of United States engineers, the report of an English engineer who has just concluded an investigation of European waterway systems for the British Waterways Commission. That report is summarized in this issue of Engineering News. It shows that the cost per mile of carrying freight on the inland waterways of France is actually higher on the average than the freight rates per mile on American railways.

Of course this does not prove by any means that there are no places where money cannot be profitably expended in large amounts for waterway improvement. It does show that the whole matter is one in which expert investigation and advice is necessary, to determine whether investment in any particular waterway is worth while. To "repudiate and condemn" expert opinions because they do not suit the promoters' purposes does not make the investment any more promising.

The improvement of the fuel economy of the locomotive engine by the utilization of part of the waste heat of the exhaust steam and the products of combustion for heating the feed-water is one of the many methods which have been suggested and experimented with at various times. Until very recent years its practicability was minimized by the fact that the injectors would not handle hot water, so that it was necessary to equip the engine with a feed pump as additional mechanism. In 1901, a committee of the American Railway Master Mechanics' Association recommended the heating of feed water by a method in which a part of the tender tank was to be cut off by a partition, and the water in this part heated by discharging into it exhaust steam from the brake pump and the cylinders. A feed pump was to be used for handling the hot water and an injector for the cold water.

At the present time, however, there are many styles of injectors available which will handle hot water. Several feed-water heating systems are now in experimental use, as described elsewhere in this issue, and one railway has adopted such a system as standard. In most of these cases the feed is delivered by non-lifting injectors specially designed for hot-water service. Some of these will take water at a temperature of 125° to 150° and feed it into a boiler carrying 200 lbs. pressure. We have a record of work on one railway where the water was taken at 134° and put into the boiler at 262° F. Where the heating is done in the tender tank, a temperature of over 125° may cause damage to the varnish unless some special provision is made to avoid this, but several of the systems now in use have the heater separate from and independent of the tender.

The advantages of a practicable system of heating feed-water are two-fold: (1) it will utilize some of the waste heat and so improve the economy of the engine; (2) it will reduce the boiler troubles and repairs due to the introduction of cold water into the boiler. As to the first matter, very few figures are available, and even these are indefinite to a large extent; but the general indication is that there is reason to expect that with proper management the economy and other advantages may be sufficient to warrant a more general introduction of the system. The information given in the article in this issue indicates that this line of improvement in locomotive performance is receiving attention both in this country and abroad.

As to the second matter, various attempts have been made to reduce the boiler troubles and repairs resulting from the delivery into the hot boiler of a solid stream of cold feed-water through an opening at the side of the boiler. Under ordinary conditions this water settles at the bottom, causing a sluggish circulation. The remedial methods which have been tried include the delivery of the feed from the check valve into a pocket or vertical pipe on the inside of the boiler, so that the cold water will overflow at a higher level and pass down through the body of hot water instead of passing directly to the bottom. Some roads have tried a perforated pipe in the steam space, so as to distribute the feed water in small streams over the surface of the body of water in the boiler. The Norfolk & Western Ry., also, has tried a special dome which has the feed connection at the top and is fitted with a series of shelves, the water dripping from shelf to shelf and absorbing some heat before it finally drops into the boiler barrel. This matter was discussed in our issue of July 12, 1906. While most of the methods have been tried experimentally only, some of them have been applied extensively in actual service, as noted elsewhere. The same purpose is accomplished by heating the feed-water, which may then be introduced in the usual way without checking the circulation or causing stagnation of cold water at the bottom of the boiler.

In the course of a notable address recently delivered by Governor Hughes, of New York, an emphatic statement was made regarding the necessity of adequate payment for those engaged in public service, and in connection with adequate payment he referred to the necessity of securing adequate tenure of office. We quote from his address as follows:

> Certainly many public officers are underpaid, and work of an extent and quality is expected of them which private enterprise would not think of attempting to command upon like terms. The scale of compensation frequently reflects the standards of earlier days when the cost of living was less and the opportunities for receiving greater rewards were not so many. The public can afford to pay its servants decently.
>
> In the great majority of places in the public service, particularly in those concerned with routine or technical work, the employment should be permanent. There is little chance of promotion, and the ordinary opportunities afforded in private business are largely lacking. This is a reason why employees of this description should be paid according to a scale certainly not below that governing payments for private work of the same sort.

We believe the ideas expressed by Governor Hughes are worth particular emphasis. The efficiency of every department of public work in these days, whether it be for cities, for states, or for the federal government, is dependent upon the quality of the work done by the men of technical ability. The only way to secure the

right class of engineers for such places is, in the first place, to select men for their ability, and not because of political preferment or "pull," and, in the second place, to give them the same certainty of tenure in their places, so long as efficient work is done, as they would have in a private business organization.

One of the most prominent Admirals of the British navy has recently gone on record with the declaration that the limit to the size of battleships has been nearly reached. The cost of the latest floating fortresses of the "Dreadnought" type has become so vast that it is felt to be unwise to stake any larger proportion of a nation's defense on a single unit. Even if the superiority of the "Dreadnought" as an antagonist to battleships of smaller type be admitted, (and this claim to superiority rests on theoretical grounds only and is yet to be proved by actual warfare) the "Dreadnought" is as likely to succumb to a torpedo or a mine as is the battleship that costs a third as much. As between a navy of "Dreadnoughts" and a navy with three times the number of battleships of smaller size, it is evident that the more numerous fleet would have certain advantages in disposition, in conducting operations over a great length of coast.

It used to be said that a first-class battleship cost as much to build as the endowment of a University and as much to keep in operation, even in peace times, as was required to carry on a University. But the cost of battleships of the present day makes the older figures look small indeed. The cost of the British Navy's "Dreadnoughts" and of their annual maintenance was recently made public in Parliament as follows:

Ship.	Capital cost.	Annual mainten'ce and ammu'tion.	*Annual mainten'ce and pay of officers and men.
Dreadnought	£1,968,083	£54,000	£68,000 †13,400
Bellerophon	1,950,131	54,000	63,000
Superb	‡1,864,429	54,000	63,000
Temeraire	1,933,537	54,000	63,000

*Including prospective non-effective charges. †Addition required if vessel is employed as a flagship. ‡Estimated first cost; actual figures not yet available.

Reduced to dollars this indicates that these British battleships cost in round numbers about 9½ million dollars to build and about $575,000 per annum to keep in commission.

In our own Navy the 16,000-ton battleships have cost to construct and equip from $6,354,000 for the "New Hampshire" to $7,911,000 for the "Connecticut." The new "Utah" and "Florida," the 21,000-ton "Dreadnoughts" now under construction will cost fully $10,000,000 for construction, armament and equipment. This is not so much in excess of British figures; but in cost of operation our higher scale of pay sends the figures soaring. For the year ending June 30, 1908, the cost of maintenance of four U. S. battleships was as follows:

"Connecticut"	$871,515
"Louisiana"	761,978
"Georgia"	807,629
"Rhode Island"	816,800

Allowing for the increased cost of maintaining the larger vessel with her larger crew, it is within the mark to say each battleship of the "Dreadnought" type will cost us ten million dollars to build and a million dollars a year to maintain, even in peace times, and this does not include the depreciation on the investment, which is enormous, since the vessel is likely to be rendered obsolete within ten years.

The slow-burning construction for factory buildings, originally advocated by the factory insurance companies of New England, has come into very extensive use and is still in high favor, notwithstanding the rapid advance of steel and concrete construction. We describe in this issue, however, the collapse of a factory building in New York which reveals a serious defect in this system of construction—a defect which ought to be more generally known to engineers. We refer to the occurrence of dry rot in portions of the timber frame from which the circulation of air is excluded. It is true that there have been in the past some notable failures of structures from dry rot, which served at their time to put engineers on their guard. The present case, however, is a new object lesson, deserving of careful attention by all engineers engaged in structural work.

The advantage which the slow-burning system had when it was first brought into use, of economy in first cost, has largely disappeared with the increasing cost of good timber and the reduced cost of satisfactory fireproofing and of reinforced-concrete construction. If in addition to this there is more or less risk in the slow-burning system of an early failure of the structure through dry rot, there would seem little object in continuing its use.

An Estimate of the Fuel Efficiency of American Locomotives.

An interesting little monograph on the fuel efficiency of American coal-burning locomotives has just been issued by the U. S. Geological Survey.* The monograph is prepared by Prof. W. F. M. Goss, Dean of the Engineering School at the University of Illinois, and is a by-product of work done under his direction in the Purdue testing laboratory on the value of superheated steam in locomotive practice.

As a result of a series of tests run on the Purdue locomotive, Professor Goss finds the disposition of the heat developed by burning coal in a locomotive fire-box to be on the average about as shown in the following table:

AVERAGE HEAT BALANCE FOR TEST LOCOMOTIVE.
(Percentages of total heat available.)

Absorbed by the water in the boiler.....	52
Absorbed by the steam in the superheater.....	5
Absorbed by steam in the boiler and superheater....	57
Lost in vaporizing moisture in the coal.....	5
Lost through the discharge of CO.....	1
Lost through the high temperature of escaping gases, the products of combustion.....	14
Lost through unconsumed fuel in the form of front-end cinders	3
Lost through unconsumed fuel in the cinders or sparks passed out of the stack.....	9
Lost through unconsumed fuel in the ash.....	4
Lost through radiation, leakage of steam and water, etc.	7
	100

It is probable that these losses are considerably less than the losses which are experienced in the average locomotive in regular railway service. In the first place, the coal used in Prof. Goss's test was of very high quality, having less than 9% ash and over 14,000 heat units per pound of dry coal. The moisture in the coal was also extremely low. In contrast with this, a very large share of locomotive service is carried on, and has to be carried on, with a comparatively poor quality of cheap coal, such as can be obtained within a reasonable distance. In the second place, the locomotive was the locomotive of the testing plant, which is kept in good order and works under the favorable conditions of an indoor laboratory, and not under the variable and often very trying conditions of road service.

It will be noticed that only 12% of the fuel fired was lost in the form of cinders or sparks passing through the tubes unburned; but it is well known that many road tests where run-of-mine coal is used, have shown that a large part of the fine coal which was fired disappeared unburned through the tubes. It is not at all uncommon, probably, for 20 to 30% of the coal thrown into the fire-box to go out unburned at the top of the stack.

The loss in the ash is also very low, compared with that experienced with dirty coals, where it is necessary to break up the clinker on the grate and shake and dump fires frequently to keep the fuel bed from clogging. Again, the superheater, which absorbs 5% of the total heat generated, is an addition in the shape of economy which has only begun to be applied to American locomotives.

Notwithstanding all these additions which must be made to Professor Goss's figures to represent conditions of locomotive road service, it is really remarkable that the locomotive boiler shows such excellent results as it does. The efficiency of the boiler and superheater as a whole in the various tests ranged from 68 to 75%. Consider the terrific rate at which a locomotive boiler is forced. The fire-box often burns coal at the rate of 100 lbs. an hour per square foot of grate surface and the heating surface evaporates water at the rate of 12 lbs. per sq. ft. per hour. Yet notwithstanding this severe forcing, the final economy of the boiler compares not at all unfavorably with the results obtained in the average stationary boiler plant.

It is worth while noting that one advantage of a locomotive boiler which enables it to attain such high efficiency is its comparatively small loss from radiation, on account of its concentrating so large an amount of power in so small a bulk. It is also favored by the fact that no infiltration of air can occur, such as often cuts down the economy of a brick-set stationary boiler.

Looking again now at the large losses in the utilization of locomotive fuel, it is interesting to note that there are other losses besides those covered in the table above. If we ask the question, What percentage of the heat energy in a ton of locomotive fuel bought by the purchasing department is actually applied to hauling trains on the road, we find the percentage to be much reduced from the above. Professor Goss himself takes up this subject and calls attention to the large proportion of the locomotive fuel which is consumed merely to get the locomotive ready for its work. He assumes the fuel consumption of all locomotives on American railways during the year 1906 at 90,000,000 tons and estimates that the heat energy in this fuel was distributed about as follows:

SUMMARY OF RESULTS OBTAINED FROM FUEL BURNED IN LOCOMOTIVES.

	Tons.
Consumed in starting fires, in moving the locomotive to its train, in backing trains into or out of sidings, in making good safety-valve and leakage losses, and in keeping the locomotive hot while standing (estimated)..	18,000,000
Utilized, that is, represented by heat transmitted to water to be evaporized.....	41,040,000
Required to evaporate moisture contained by the coal	3,600,000
Lost through incomplete combustion of gases..	720,000
Lost through heat of gases discharged from stack	10,080,000
Lost through cinders and sparks.....	8,640,000
Lost through unconsumed fuel in ash.....	2,880,000
Lost through radiation, leakage of steam and water, etc.....	5,040,000
	90,000,000

Using the figures in the above table, it appears that only 45% of the heat in a ton of coal bought by the purchasing department for locomotive use is actually effective in evaporating water for use in the locomotive engine to propel trains. It may be interesting to inquire what per cent. of the heat so utilized in making steam is actually converted to mechanical power in hauling trains.

Suppose we assume the average steam consumption of the average locomotive to be 25 lbs. of steam per indicated horsepower, and that 70% of the work done on the locomotive pistons is effective in producing a pull on the drawbar at the rear of the tender. This latter figure may be thought too low in view of the results obtained in locomotive testing laboratories. It must be remembered, however, that the testing laboratory results, which show a considerably higher efficiency for the locomotive as a machine, do not take into consideration the work done on a locomotive on the road to accelerate its speed and to lift it up grades. Taking these factors into consideration, 70% seems as high as it is safe to go.

Let us now combine these assumptions, viz.: That of the total heat in the locomotive fuel purchased only 45% is actually utilized in making steam to be applied in the cylinders of locomotives in doing useful work, that the steam consumption of the locomotive averages 25 lbs. per indicated horsepower hour, and that of the work done on the locomotive pistons 70% reappears as pull on the train. Combining all these, we find that only about 2¾% of the heat in the locomotive coal finally appears as useful work in hauling trains.

This result checks fairly well with the results obtained in the tests of the Pennsylvania locomotive testing laboratory in 1904. These results showed under the very favorable conditions of

*Bulletin 402, U. S. Geological Survey, "The Utilization of Fuel in Locomotive Practice," by W. F. M. Goss.

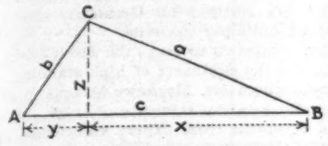
the testing laboratory a fuel consumption of about 4 lbs. per horsepower hour for simple freight locomotives. Deducting for the coal consumed in getting ready for work, etc., as above, and for the more wasteful conditions of road service, the result attained is about the same.

LETTERS TO THE EDITOR.

A Simple Method of Solving Oblique Triangles When the Three Sides are Known.

Sir: Below is a handy formula, which is seldom used, for solving oblique triangles when the three sides are given.

Given the sides a, b and c in the triangle $A\,B\,C$, see sketch herewith. From vertex C drop a perpendicular on $A\,B$; call its length z and the segments into which $A\,B$ is divided x and y, so that $x + y = c$. Then x and



y can be found without the use of trigonometric functions or involved square-root formulas, and from them the other parts of the triangle computed.

The formula is:

$$x - y = \frac{a^2 - b^2}{c}$$

from which we get x and y by

$$x = \tfrac{1}{2}\,[(x + y) + (x - y)]$$
$$y = \tfrac{1}{2}\,[(x + y) - (x - y)].$$

These latter formulas are obvious. The other is proved thus:

$$b^2 - y^2 = z^2 = a^2 - x^2$$
$$\therefore\ a^2 - b^2 = x^2 - y^2 = (x - y)\ (x + y)$$

whence

$$x - y = \frac{a^2 - b^2}{x + y} = \frac{a^2 - b^2}{c}$$

The angles may then be found by

$$\cos A = \frac{y}{b}$$

$$\cos B = \frac{x}{a}$$

and z may be found from these ($z = b \sin A$) or directly from y and b or x and a ($z = \sqrt{b^2 - y^2} = \sqrt{a^2 - x^2}$).

F. W. Rizer,
Asst. Engr., C., B. & Q. Ry.

Chicago, Ill., Nov. 9, 1909.

A Defect of Lapped End Connections of Lacing Bars.

Sir:—Although we know little about the stresses in a built-up steel column, there are some assumptions often made in regard to lacing bars that in my mind lead to absurd conclusions. An analogy is often drawn in the mind of the engineer, between a Warren truss and a column with lacing. Reasoning by deduction, the lacing bars of the columns are made by the designer to intersect in a rivet, just as the eyebars and web members of the analogous truss are made to intersect in a pin. The fallacy of such an analogy is that two bars cannot be said to intersect if they are not in the

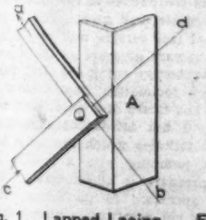


Fig. 1. Lapped Lacing Connection.

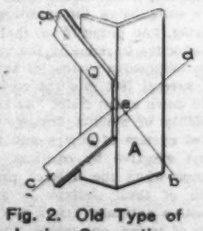


Fig. 2. Old Type of Lacing Connection.

same plane. Just imagine a bridge truss the panels of which are in different planes! Yet the standard lacing so much used is analogous to just that.

In Fig. 1 the bar a b never intersects bar c d, because they are not in the same plane. Bar c d is therefore subject to a large bending moment. In Fig. 2, bar a b and bar c d intersect in the point e. Here the angle or channel A is subjected to a bending moment.

It is a matter of choice whether to make a column laced like Fig. 1, throwing a bending moment on the slender lacing bar, or like Fig. 2, throwing a bending moment on the stiff angle or channel. If the angle take the bending moment, it does so with less deformation of the lacing-bar rivets than if the bars take the bending moment. And here is the root of the whole matter: If the lacing bars are not held in place in the most rigid manner possible, they do not prevent deflection in as full a measure as they might, and the strength of the column is impaired.

The conclusion I draw is that lacing bars should be neither lapped nor crossed.

It seems to me lacing bars could sometimes be placed in pairs, so as to stress their end rivets in double shear, making a most rigid attachment. Whether this is practicable or not, that practical system is best which is most rigid. "That which is most useful in practice is most correct in theory." [Bacon, "Novum Organum"].

Benton Lattin.

Philadelphia, Pa., Nov. 4, 1909.

Transportation on the Mississippi River and Its Tributaries—The Plans of the Mississippi Valley Transportation Co.

Sir: I have just finished reading in your issue of Nov. 4 your editorial on the restoration of traffic on inland waterways and the report of the Board of Survey about our traffic.

I am going to ask for some space in your columns to reply to this with a definite statement of exactly what exists out here, because the matter is of national importance and is clouded by a great deal of misunderstanding. I think if we state definitely just what condition the river is in and what we are doing to use it, it will help your readers to form a fairer idea of the purpose and probable use of the channel improvement which the Government is asked to make.

First: In regard to the statement on p. 490 by the Government Commission about the channels which exist—a statement which is borne out entirely by the engineers' reports, but which as far as the pilot is concerned is absolutely untrue. In this statement the Commission asserts that it has been possible for several years, even during low water season, to freely send boats of 9-ft. draft to Cairo, 8-ft. draft to St. Louis and 4½-ft. draft to Chicago. This is not true. There has been for several years in the Mississippi River below Cairo what is called a 9-ft. channel. If you have ever navigated a vessel yourself, you know you must have some water under the bottom of the boat. Two feet is really the margin necessary for safely floating a boat over a bar, though we do it on very few inches when we have to, and as everyone knows, in going down through the Sault Canal, the big lake steamers load as near the bottom as they dare.

It is necessary to explain what the engineers mean by a 9-ft. channel. In the river below Cairo nearly all of the bends are from 50 to 100 ft. deep, and if my memory is correct, there are about 13 bars at which trouble can be expected in low water, with less than 10 ft. on the crossing. The purpose of the Government is to dredge these bars as low water approaches so as to maintain the 9-ft. channel on them. When the bar has been dredged, the Government engineers and their employees making soundings at very frequent intervals, cross the entire breadth of the channel and indicate on a chart the depth of water at every point; then among these soundings, they trace a line, often very tortuous, which follows the deepest soundings and indicates that by following this line there is somewhere in the river a theoretical channel 9 ft. deep.

This deep line of the channel varies from day to day, back and forth through the real channel as the river moves. It is not indicated in any way whatever except as the main channel is roughly indicated by lights placed on the shore and moved from time to time. This 9-ft. ditch may not be more than 10 ft. wide. It is impossible for a pilot to find it or to use it. A fleet of barges with their tows is 100 ft. wide, or may be 200 ft., and the pilot must find a channel wide enough to take them through and he must have a depth of water at all bends sufficient to allow for the turning and moving of this fleet without danger of striking the corners of his tow in the bends of the channel. There has never been at any low water season any channel below Cairo when it was safe to take a tow of barges, even small, not more than 100 ft. in width, drawing more than 7 ft. of water down the river, and often for 50 days in the year it is not practical to go down with much over 6 ft.

Above Cairo, the engineers assert there is an 8-ft. channel, but this again is not true in any practical way. Many pilots who have sounded the channel carefully have declared they could not find more than 6½ ft. at low water anywhere over certain crossings. But admitting there may be 8 ft. somewhere, there has not in history been a low water season, except those unusual years when the river stays high through summer rains, when it was safe to load and go out of St. Louis down stream drawing more than 6 ft., and very seldom when one would carry more than 5 ft. In a practical boat and find a practical channel which would carry it. Two hundred days in the year one could come into St. Louis drawing 8 ft. in a 9-ft. channel.

As for the 4½-ft. depth to Chicago, the statement is laughable. Nearly every low water the channel at Alton between St. Louis and the mouth of the Missouri River, drops to 4 ft. and it is hard for a vessel drawing 4 ft. to get through. The Illinois has a depth of 7 ft. up to La Salle, but no boat which can be used on the Mississippi River can ascend beyond that point, for the 4½-ft. canal to Chicago admits vessels only 18 ft. wide and rising not more than 11 ft. above the surface of the water. That is to say, only little old-fashioned canal boats such as cannot be profitably towed on the Mississippi.

The channel to St. Paul is a practical 4-ft. channel. That to Kansas City is not a 4-ft., but a 3-ft. channel, and very uncertain and full of snags. That to Sioux City is not more than 30 ins. in summer, and on the Ohio the statement that it has a 9-ft. channel is a laughable attempt to make people think the Ohio is a navigable river. The Ohio carries out some 4,000,000 tons of freight every year to the Mississippi and handles perhaps 11,000,000 tons at home. It is the best sign we have that rivers will float freight, but it is all a flood-water business. Last year a friend of mine drove his automobile across the Ohio in its lower reaches without interfering with the engines or getting his feet wet. In the same season a traction engine and a threshing machine went across under their own power near New Albany. To be sure they only call the 9-ft. channel a "mean," but it is not even that. The Ohio rises quickly and falls quickly and summer water prevails a long time.

Twenty inches is a liberal depth for the Ohio during the summer and it was eight months last year between fleets of the Monongahela Consolidated Coal & Coke Co. That is to say, this big fleet lay idle for eight months at an expense of several thousand dollars a day for upkeep and pumping, repairs, and all that is necessary to maintain a fleet. Eight months of idleness will kill any boat line and destroy the traffic on any river.

I have given you this statement not from the point of view of a theoretic student of the river, although I am familiar with its channels; but from the point of view of a man engaged in the carrying business on the river, and from information gained by personal observation, and by enquiry from men who are continually in the channel. It may sound very depressing, but I want now to answer your editorial and present the other side of the question, by a brief statement of what we are doing out here actually to revive transportation.

The death of the old type of river boat, the flat bottom stern wheeler and the side wheeler, on which all known plans are based, came about through natural causes, just as the stage coach vanished from our highways. This old mixture of freight and passenger had no economy in fuel and freight handling, and had to operate in a channel, which as late as 1900 was so uncertain as to be uninsurable and practically impossible at low water stages.

If you remember an article in "Everybody's Magazine" last April entitled, "Making Rivers Work," or if you will refer to it, you will find there set forth the reasons why our rivers failed and some of the reasons why the German rivers succeed. It is not true as stated in the Commission Report that the freight rates on German rivers are even higher than on American railways. The freight rate on coarse goods on the Rhine, up and down stream, averages little more than one mill per ton-mile, as I know from actual observation; whereas the lowest rail freight rate in this country is 3 mills per ton-mile and the average 7 mills.

What is needed to make traffic profitable in competition with the railways, even in the unstable channels which we now possess, is the practical development of the other two elements of traffic; boats suited to the rivers, and terminal facilities which eliminate the expense of transhipment of freight. When these are installed and traffic on the river is considered not at all in connection with the number of people per sq. mile on the river bank who may ship cotton bales by packet boat, but as a link in through movements of freight reaching from 180° east of New Orleans to the same point 180° west of New Orleans, to be used in connection both with the railways and with the ocean steamship lines, the Mississippi begins to have a new interest and a new meaning.

At the risk of seeming to advertise our business (I hope you will overlook this intrusion) we have now undertaken in the Mississippi definitely to establish this sort of traffic. The company of which I have the honor to be a director and secretary, is now raising a capital stock of $10,000,000 with the cooperation of merchants in all of the cities in the valley, and we expect to increase that capital very soon to $25,000,000, to take care of the business which is growing up ahead of us.

We are now building some of our boats, but our interest for the public lies chiefly in the types which we have designed. Our tow-boats for handling our fleets in the main river will draw about 30 ins. of water. They will be side wheelers after the Austrian type and will each have 2,000 HP. They will be entirely different from anything now floating on American waters, with compound engines, Scotch boilers and everything aboard of them designed for lightness and strength. The barges which these will handle are designed for use in a fluc-

tuating channel for carrying cargoes of every sort, both bulk, such as coal and grain; materials in packing, such as cement and hay and coffee, and the high-class freights, such as dry goods. The barges of this type for the lower river are rectangular, with a long rake about 30 ft. at each end, so they will run out of the water easily, this type having proven very easy to tow. They will be 350 × 50 ft. and 10 ft. in depth. They will be entirely decked over, but equipped with hatches their entire length spaced 12 ft. c. to c. These boats will, of course, be of steel, strongly built, divided into compartments, and will draw, when light, 15 ins. They will carry about 1,200 tons each, on 4 ft. of water; 2,800 tons on 7 ft.; and when loaded to full capacity, about 3,900 tons. They will cost us $52,000 each.

In addition, we have a smaller type, four of which in a group will go through one of the upper river locks. These are 148 × 36 ft. and will carry 1,400 tons each when they are loaded, but ordinarily in the upper river about 750 tons each. These barges are so designed that they will carry all kinds of freight with great security, but those which we use for the Missouri River will be further reinforced by ½-in. armor plates on the bows and quarters to insure safety against snags.

The frequency of the hatches enables us to do away altogether with trucking and handling, and to substitute at every city overhead cranes and derricks for hoisting out and stowing cargo. The "house freight" handled by the railroads costs about 40 to 50 cts. a ton every time it goes through a railroad freight house. This same freight can be handled as we propose to handle it, for as little as from 4 to 10 cts. a ton. Handling by roustabouts, in the old-fashioned river way, costs from $1 to $15 a ton.

Our plans call for the immediate expenditure of probably a million dollars on these freight-handling terminal devices at St. Louis, Cape Girardeau, Cairo, Memphis, Helena, Vicksburg, Greenville, Natchez, Baton Rouge, and New Orleans, and this provides only for the traffic we will carry next year and does not take into account our expenses on the upper Ohio, the upper Mississippi, the Illinois, the Missouri and all of the tributaries.

The fleet which we propose to build in the next two years numbers 200 barges and 30 tow-boats, and this will require an expenditure of our entire capital in equipment, so we will have to accumulate a fund from earnings or increase the capital stock.

Now as to the profit from carrying this freight and the freight we are to carry. We have already arranged many of these items, although we have not reached the stage of making definite contracts. We do not propose to go into a rate-slashing business, but we find we are able to handle freight on the average river hauls for about 0.8 mill per ton-mile, averaging the up-and-down-stream traffic, actual cost of transportation.

We intend, however, as a business proposition to take on high-class freights only at fair differential on the railroads. This amounts to 25 or 30% less than the railroad rates. On this basis we have found the railroads willing to cooperate with us and have already entered into agreements with several of them to establish common terminals and trans-ship freight by which the river becomes a part of the long through haul; the railroad, the collecting and distributing factor. This, you will recognize, is the ideal situation of the handling of cargo. On coarse goods, of course, when the railroad is virtually unable to compete, we will make our rates so as to get the trade. Thus on coal from the Illinois to New Orleans, we will probably charge something like $1 a ton, over the route in which the railroads cannot handle fuel for less than $1.50. We will go up the Missouri River after grain, with a rate which should add 3 cts. a bushel to the farmers' price. We expect to carry cement, hay and all those bulky things in barge-load lots and to handle them securely and safely.

All these materials, including high-class goods, are to be had now, so that we are confident of carrying, as soon as our ships are afloat, not less than 1,000,000 tons of cargo. To carry it will strain the capacity of our first years' fleet of three powerful tow-boats and 20 barges. The income returned by this amount of cargo will be about $1,500,000, of which not over 40% will be operating expenses, including upkeep of terminals. We have, as a matter of fact, 5,000,000 tons of freight a year in sight that we can carry, and we believe in ten years this company alone will be carrying 10,000,000 tons.

We are not establishing a monopoly. We hope to see public terminals at every city, which all lines can use in common and free cooperation and through rating with the railroads. We have in the West the advantage of state commissions which in nearly all states make local rates, so that by landing our freight at a terminal in any state, we have free facility to ship cargo to any points on the railroads in that state.

This is, of course, the first attempt ever made to introduce modern facilities into American river traffic, and we think it is worth your note on that account. We think it is worthy of attention for another reason. Your paper reaches the principal engineers in all departments of American engineering. The Mississippi as a freight carrier has absolutely lacked in all departments the consideration of our engineers. Scarcely a single steamboat or terminal installation can be found which has received the consideration and study which the engineers give to electric and steam railroads and their bridges, and to the telpher and transfer establishments in freight yards and factories. We need that attention now on the river to devise the best type of shallow draft boats and the best types of propulsion. We have a thousand problems to solve on every tributary, and having come to the point where we are willing to risk our millions and give our time and our whole attention to this task—restoring the Mississippi system to America as a freight carrier, handling cargoes in these huge figures as they are handled on the lakes, we ask your sincere and entire cooperation as far as you are able to give it.

We are not crying for deeper channels. We regard that question as settled. We are going ahead with the best we have now until the irresistible impulse of the popular demand establishes the revetments on the banks which will make the Mississippi Channel as safe and permanent as the New York Central Railroad.

Thanking you for your attention and hoping you will find space for this in your pages at an early issue, I am

Very truly yours,

John L. Mathews.

New Bank of Commerce Bldg., St. Louis, Mo., Nov. 15, 1909.

[It seems to us that the above letter, assuming that the claims made by Mr. Mathews for his river transportation company are well founded, is an admirable endorsement of the very report which Mr. Mathews in the first part of his letter attempts to criticize. As those who have followed this matter closely are aware, the Board of Engineers in its report stated that, from all the evidence now available, water transportation on the Mississippi could be carried on as economically with 9 or 10-ft. draft as with 14-ft. Mr. Mathews claims that with the fleet of boats his company proposes to install, they can handle freight *on the present river* at an average cost of about *eight-tenths of a mill per ton mile.* If they can do this, or anything approaching this, what possible object could there be in the Government spending many millions of dollars to increase the depth to 14 ft.?

We cannot, however, pass without comment Mr. Mathews careless and sweeping criticisms of the work of the U. S. Engineers in river improvement. We may not take space to point out in detail each of the statements in which he errs, but will select only two or three typical examples. Mr. Mathews poses as an expert on river navigation and says "two feet is really the margin necessary for safely floating a boat over a bar, though we do it on a very few inches when we have to."

In contrast with this we would place the fact that Germany *officially* uses 18 ins. as the margin for safe navigation, Belgium uses 12 ins., and France 8 ins. Over the soft bars of mud and silt in the Mississippi, boatmen commonly load within a few inches of the bottom; and there is no basis whatever for the claim of 2 ft. as a necessary margin which Mr. Mathews makes.

Next as to Mr. Mathews claim that the channel which the Government dredges across a bar is a tortuous line which "may not be more than 10 ft. wide." In contrast with this we would place the fact that the channels across the bars below St. Louis are dredged to a width of at least 200 ft. and are buoyed on each side of the dredged channel. Further, these channels are usually dredged deeper than the 9 ft. called for, as a safeguard against boats bumping on the bottom and early redredging.

Doubtless Mr. Mathews can secure statements from river pilots and vessel captains finding fault with the channel; but such statements prove nothing and ought not for a moment to be accepted by any engineer. Vessel pilots make soundings with a line along the route their boats follow and may occasionally send out a rowboat. The Government engineers sound all around and in each channel with a rigid pole, both before and after dredging. It is entirely natural that the boatmen should try to place the blame on the channel when a boat runs aground; but the actual cause is usually either some accident to the machinery or an attempt to save time by cutting across a point instead of following the channel or loss of the channel by mistake or fog.

No doubt Mr. Mathews would say that the Government ought to improve the channels over all the bars to such a depth and width that there would be no chance of boats grounding; but neither the Government nor the Government engineers can accomplish the impossible. Already the Government is spending more money every year on the Mississippi than it would cost it to make a free gift to the shippers of carriage by rail of all the goods that are carried on the river between St. Louis and New Orleans.

One more comparison of Mr. Mathews figures with facts and we are done. He says above: "The freight rate on coarse goods on the Rhine, up and downstream, averages little more than one mill per ton mile."

Contrast this figure with that given by Mr. W. H. Lindley, M. Inst. C. E., of the Royal Commission on Canals and Waterways of Great Britain. We have quoted direct, in another column, from an English contemporary, Mr. Lindley's official report and it shows average freight rates for coal and iron ore shipped on German rivers at 3.7 mills to 4.1 mills per ton-mile.

We feel compelled to make the above statements in justice to the engineers of high standing in the profession whom Mr. Mathews attacks in his letter as well as in the interests of truth. Since he claimed to speak from expert knowledge, it was necessary to show his inability to qualify as an expert.

And it is the information and advice of real experts that the United States needs if it is to be guided safely through the present craze over waterway improvements. It may, indeed, give a temporary stimulus to business for the Government to sink great amounts of borrowed money in public works which yield no benefit commensurate with their cost; but such prosperity will be but short lived—and must be dearly paid for in the end.—Ed.]

The Design of the Panama Canal Locks.

Sir: The writer is very much interested in the articles appearing in technical papers from time to time relative to the designs for locks and other structures for the Panama Canal. From a careful reading of these articles it appears that those in charge have a perplexing problem to solve. Your issue of July 15, 1909, gave quite a complete description of the design for the Gatun flight of locks, but subsequent issues of "The Canal Record" seem to indicate that the designers are not yet sure of their ground. "The Canal Record" for Sept. 29, 1909, states:

> The plan as changed is to drain the back of the lock walls below the intermediate gates. There will then be no reason to fear that the upward pressure will develop under the lower portion of the floor. The anchors recommended in the report, therefore, will not be placed.

The report referred to is the report of a Board appointed by the Chief Engineer to investigate the foundations for the lock and recommend plans for the lock floor. The design recommended as published in Engineering News of July 15, appears to introduce three uncertainties in lock floor design in the hopes of securing one certainty. These uncertainties are efficiency of (1) a curtain wall to intercept the underground flow of water, (2) a flat floor anchored to the rock foundation, (3) a system of sumps and telltales by which the upward pressure may be determined. The above-mentioned change introduces another uncertainty, as the continued efficiency of the best drain is uncertain unless it is considered certain to fail.

The curtain wall is designed to be placed across the upper end of the lock walls and alongside the sill of the emergency dam, thence along the outside of the lock walls to a point below the intermediate lock gates. The Board fearing, and properly so, that this curtain wall would not be effective in reducing the upward pressure on the floors, also designed a system of anchorage using old steel rails set several feet into the rock foundation, hoping thus to hold down a flat floor. As the Board also questioned the stability of such a design, it has introduced a complicated system of sumps and telltales which can only become effective by constant pumping with a system of pumps when the upward pressure is objectionable. As each of these designs is uncertain in its action, the question naturally arises why not substitute a design certain of action, one whose stresses are susceptible of careful and accurate analysis. It is believed that such a design is found in an inverted arch floor, as the stresses in such a floor can be accurately determined by analysis and their location, intensity and direction of the action known beyond any question of doubt. Such a floor also provides a good bed for the lateral culverts and should be carried throughout the entire length of the flight of locks.

The location of the curtain wall outside of the side walls is further objectionable in that it leaves a groove 6 ft. in width between the lock walls and the rock surface. It is practically impossible to so place the backfill material in and above such a groove as to avoid settlement.

The filling above the groove will undoubtedly arch across at top of groove. The material placed in the groove will settle away from the arch formed above it, thus providing a free passageway for water back of the walls which will greatly increase the horizontal pressure. The only reason apparent for placing the curtain wall back of the lock walls is a fear that the rock foundation is more compressible than the concrete curtain wall.

Investigations made as to the strength of this rock in compression show that for loads much in excess of those to be imposed by the lock design, the foundation is practically incompressible and as the load under the outer toe of the side walls is very moderate, it is not at all probable that the foundation would be compressed to an injurious extent. It is suggested that the curtain wall be entirely omitted back of the lock walls but should be placed under the locks somewhat as designed and extended entirely across the excavation, reaching up to the elevation of the lock coping. Such a design would somewhat reduce the flow of water under the upper ends of the locks and also reduce seepage into the backfill.

From a study of the topographical conditions and the backfill available, it seems that the designers are ultra-conservative in assuming that the backfill will be water-soaked up to elevation 80, for it is almost impossible to have such conditions obtain. If the change of cut-off wall herein noted were made and the culverts given a rectangular form (a curved top if desired) the side walls could be narrowed to a width of 42 to 45 ft., reducing the concrete required nearly 15% and largely reducing the excavation.

Moreover, the plans published in Engineering News show the surface of the lock floor 15 ins. below the top of the miter sill. Such a design results in no benefit to navigation, increases the amount of excavation and concrete required and results in greater horizontal pressure in the lock walls. Also the all-important feature of ample protection to miter sills from being struck by passing boats is lost by lowering the lock floor.

Relative to the design of the middle wall and the culverts therein, the writer is unable to endorse the statement that

in order to make room for these two culverts, however, the center wall would have to have its thickness increased to 80 ft. and even then the stresses would have been somewhat excessive under certain conditions. It is certain that if the middle wall with a width of 60 ft. is stable with one culvert, it will not require an extra 20 ft. in which to place the second culvert. A careful analysis of this wall will show that two culverts, if properly located and proportioned, can be placed in the 60 ft. wall without resulting in excessive pressure either in the concrete or the foundation.

As now designed, one or the other of the locks will have to be operated from one side only. It will be found impracticable to operate the center culvert in filling both locks at all times, so that if the canal is ever taxed to its full capacity, its efficiency will be greatly reduced by not having two culverts in the middle wall. The design also introduces a complicated system of secondary valves for controlling the side culverts. One lock will have to be filled from one side only, resulting in cross currents and undue surging of the boats using the lock. If the lock is shortened by the use of intermediate gates, the velocity of water through the floor openings will be greatly increased, thus producing additional turbulence to the water. If the culverts were all made rectangular in form, they could be reduced at least 3 ft. in width, would be much more easily and cheaply formed and the concrete could be more easily deposited around the forms. It will be found very difficult to crowd the concrete under the circular culverts sufficient to produce a dense wearing surface.

This work is of national importance and should be so designed that while fully meeting the requirements of the most careful and rigid analysis, there shall not be a gross waste of material nor an inefficient and inferior type of structure built.

M. G. Barnes, M. Am. Soc. C. E.

Albany, N. Y., Oct. 29, 1909.

[Proof of the above letter was submitted to Col. H. F. Hodges, of the Isthmian Canal Commission, with a request for comment on the questions raised by Mr. Barnes. We append his reply as follows:—Ed.]

Sir: Mr. Barnes' views on the design of the Panama Canal locks, and especially of the floor of the upper Gatun lock, as expressed in his letter to Engineering News, are entitled to consideration. The writer, as one of the members of the board which selected the floor design, takes pleasure in setting forth some of the reasons which led him to favor it.

Either a flat floor or an invert, if made strong enough, would undoubtedly be efficient as a bottom for the upper lock at Gatun. The anchored flat floor designed for the chamber is less expensive than an invert and involves, in the writer's opinion, no uncertainty whatever. The anchoring power of the old French rails in the soft sandstone was tested very thoroughly and found to be great. The floor is strong enough to resist any under-pressure to which it can be subjected. The writer preferred it to the invert, not only on the score of economy, but because his views as to the determinacy of all the stresses in the two classes of floors is different from that expressed by Mr. Barnes. The latter, however, probably does not intend to be taken literally in his statement that in an inverted arch floor the stresses can be "accurately determined by analysis and their location, intensity and direction of the action known beyond any question of doubt"; such certainty would be especially difficult of attainment in a case like that in question, where even the conditions of loading are unknown.

It was originally planned to anchor the thin floor in the lower part of the upper lock, where it rests on the conglomerate, but upon further consideration, in the light of the experience gained in putting in the upper part of the floor, and from observation of the excavation after the curtian wall trench had been dug, it was thought safe to omit the anchorages below the intermediate sill, and to backdrain the wall in this part of the lock.

In regard to carrying the invert the full length of the lock flight, as proposed by Mr. Barnes, the writer will not be prepared to speak with certainty until he has seen all of the rock not yet exposed in the lower part of the flight; but, if that still to be uncovered proves to be as good as that which he has already seen, he would think that no special precautions are necessary there, whether in the form of an invert or otherwise, except perhaps for a short distance at the upper end of the middle lock.

Mr. Barnes appears to doubt the "efficiency of a curtain wall to intercept the underground flow of water." It is acknowledged that the box which the wall forms, being open at the lower end and the bottom, may allow pressure to develop, although it will probably reduce it considerably below the lake head, and restrict materially the quantity of water producing it. Nevertheless, the writer sees no reason to doubt that it will intercept the main flow; and it is to be put in largely for that reason. The indications are that, under the lake head, there might be actual flow of water in the stratum of soft sandstone. This flow, of course, would be slow and general in its character, rather than localized in streams. Nevertheless, it was thought best to stop it by the curtain wall lest an actual material removal of particles of the sandstone might take place. The excavation for this wall, which has already been made, has proved to be a very efficient check to the ground water which now exists.

The writer is not at all sure that this curtain wall is not unnecessary, but he certainly considers it a desirable precaution and feels that it is fully justified in a work of such magnitude.

The excavation for the curtain wall was made behind the side walls instead of under them in order to avoid founding the heavy side walls in part on concrete and in part on the natural rock. It was feared that the materials would compress differently under the loads, and that the lock wall might suffer damage in consequence. Some of the foundation material is unquestionably softer than concrete.

A cross curtain wall, somewhat as suggested by Mr. Barnes, was discussed. If extended only across the lock-pit, it might still permit a flow in the stratum of soft sandstone around its ends and thence under the lock floor; while, if carried at full depth to a safe distance on either side, it would involve excavating a deep trench through the rock outside the lock-pit. Such excavation would have been much more difficult and costly than that involved in widening the pit to allow the curtain walls to run back of the lock walls. Furthermore, the test-pits indicated an underground flow from the eastward, which would probably not have been stopped by a transverse wall of reasonable length.

The sumps and tell-tales which Mr. Barnes criticizes are intended more for purposes of observation than for relief, although relief may be given by them, if need should arise. They cost extremely little, and should give information as to the condition of pressure under the floor. The latter can be exposed to full pressure only when the lock has been unwatered for any purpose; hence, the exposure will last only a relatively short time. The possibility of relieving, during this time, any pressure which may be found to exist, is a desirable asset, even though it may not necessarily be put to use.

Mr. Barnes finds further fault with the location of the curtain wall, because of the groove formed between the rock and the back of the side wall, which he thinks will be difficult to back-fill so that water will not get into it. There ought to be no difficulty in back-filling the trench so that the material will not arch over it; but the writer has given no especial thought to excluding the water here, since the side walls at the upper end of the lock are calculated to withstand saturated back-fill with ground water at plus 90, i. e., 2 ft. below the coping. Under any circumstances, he would hardly consider it safe to rely upon the absence of water pressure behind the lower part of the wall near its upper end. The distance through which this pressure may exist is not determinate, since the future slope of the water in the body of the dam, and in the natural hill is not known.

A great deal of study was given to the disposition of the culverts in the middle wall. The writer was not able to satisfy himself that two culverts large enough to be of material value could be used safely without a considerable increase in the cross section of the wall. It should be remembered that the critical part of the middle wall is not 60 ft. wide, but 43 ft., at the gate recesses.

As the middle wall at Gatun is 3,880 ft. long, exclusive of the approaches, a considerable addition to its area of cross section means a great increase in cost. To avoid this, the single culvert was adopted.

A maximum of 3 ft. per minute has been assumed as the permissible rate for the rise or fall of the water surface in filling or emptying the lock. It is hoped to be able to fill the largest of the locks in less than 13 minutes, using both culverts and without exceeding this rate. The single side culvert will fill it in about five minutes longer time.

There need be no loss of efficiency due to the fact that under certain circumstances consecutive and twin locks cannot use the middle culvert simultaneously. Even in case of a continuous stream of shipping using the lock flights, vessels following each other will be separated by one clear lock in each flight. It follows, therefore, that the middle culvert can be used independently by all the locks which will be occupied in either one of the flights. It will certainly take a longer time to move a large vessel into one of the locks, moor it, and prepare the lock for change of level, than it will to fill or empty the lock. The vessels in one flight will consequently be occupied more than half the time in moving, and less than half the time in using the culverts. It follows that the vessels in the other flight will have more than half the time to use the culverts, while the first series of vessels in the twin flight is moving from lock to lock, and tieing up. There need, therefore, be no interference whatever in the use of the middle culvert, which will be available for both flights instead of one, as stated by Mr. Barnes. It will require system and care in moving the vessels into and out of the locks, but such system and care must necessarily be observed in any event.

In this connection, it may be noted that it is not necessary to use the middle culvert during the entire period of filling or emptying the lock, but that the side culvert will be sufficient to keep up the estimated rate of filling during the earlier few minutes of the period, even in the case of the largest locks, and that the middle culvert need be called on only in the latter part of the lockage in order to keep up the required rate as long as possible when the levels are approaching equalization.

It should also be noted that the middle culvert is not needed in order to fill any except the 1,000-ft. and 900-ft. locks with the desired rapidity. The side culvert alone is sufficient to fill the 350-ft. and 550-ft. locks in about the same time that both culverts will fill the 1,000-ft. lock. While the middle culvert may be used with these locks without interference, as just stated, it is the writer's belief that in the operation of the locks only the side culvert will be used to fill and empty the smaller locks, and the aid of the middle culvert will be reserved for the relatively infrequent 1,000-ft. and 900-ft. lockages.

Mr. Barnes criticizes the subsidiary culvert valves incidental to the use of the single culvert in the middle wall. It is admitted that this feature of the design introduces a number of additional moving parts, but the objection to increasing the number of valves has not the force that it would have in case these valves had to be moved separately or by hand. All of the subsidiary valves on either side could, were it desired or necessary, be regulated by a single switch and all made to move simultaneously in response to a single motion of the operator. The valves themselves are extremely simple and of a well-known type, and it is believed that no trouble will be occasioned by the fact that there are ten of them on each side of the culvert. The use of such valves lends itself conveniently to the transfer of water from one lock to the twin, by which, under certain conditions, a considerable saving in water can be made. Under all circumstances, the writer sees no justification in going to the additional expense necessary in order to provide, in the middle wall, separate culverts for each flight.

The writer has no thought that surging in the lock will be troublesome when the side wall culvert only is used. This culvert supplies lateral culverts which pass under the floor perpendicularly to the axis of the lock. The water gets into the lock chamber by upward flow through holes in the roofs of these laterals, which are distributed practically uniformly over the entire area of the bottom. It would certainly be possible to distribute these openings so that no surging will result; and the writer believes that the nearly uniform distribution adopted will accomplish that end. He has never heard that the surging is troublesome in the Ohio River locks, which have the same width as the Gatun locks. In these the water is admitted across the lock through sixteen holes in the upstream half of the river wall; and is not even carried under the lock floor, but allowed to flow directly into the chamber. The lift is small, to be sure, but the velocity of the water as it enters the lock is greater than the average velocity which the water entering the chamber of the Gatun lock will have, if the adopted rate of filling be adhered to.

Mr. Barnes states that the shorter locks will have increased velocity of entrance. The writer sees no force

in this criticism. The amount of water admitted is regulated at the valves, and there is no theoretical need for letting it into the small locks at a greater velocity than into the larger ones, if the rate of rise or fall of the level be kept at 3 ft. per minute. In point of fact, owing to lack of exact uniformity in the distribution of the lateral culverts, the average velocity in the openings in the lock floor will be very slightly less in case of the 550-ft. lock than in case of the 1,000-ft. lock if the stated rate be maintained.

A number of the lateral culverts are already in place. There has been no difficulty in avoiding the trouble in forming them, feared by Mr. Barnes.

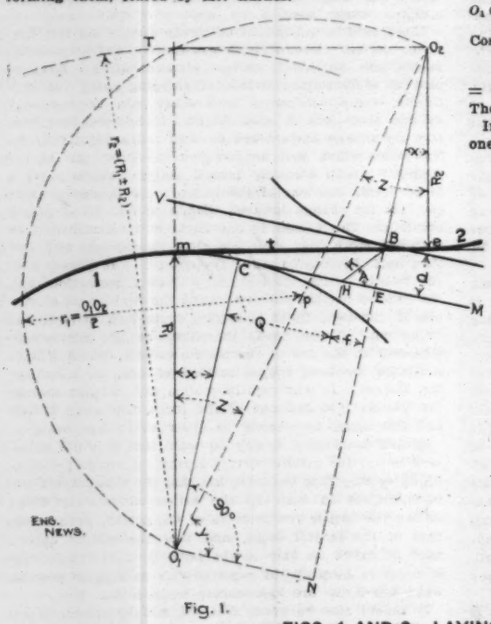


Fig. 1.

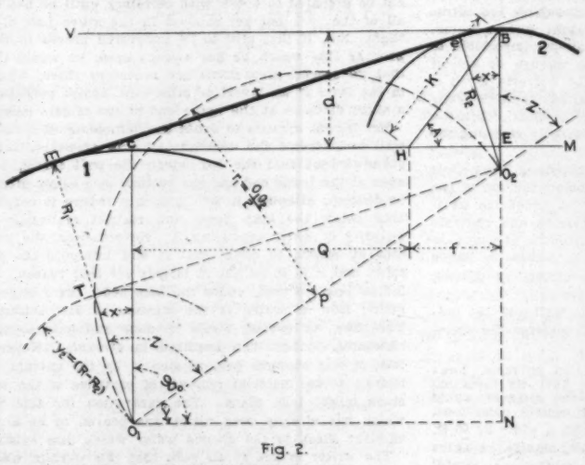


Fig. 2.

FIGS. 1 AND 2. LAYING A TANGENT TO TWO CURVES.

Mr. Barnes criticizes the design for following the practice usual in large locks, of placing the floors at a level slightly below the sills. At Sault Ste. Marie, the lock floor is on the same level as the lower sill, but in all other large locks of which the writer has information it is dropped a little below the sill level. The guiding reason for doing this in the Panama Canal is to provide more room under the vessel's bottom in the lock, both in order to allow the water to circulate more freely when it or the vessel shall be in motion, and to prevent possible injury from some small sunken obstructions which may drift into the lock or may be dropped from a passing boat. The upper sills are amply protected by the bottom of the Culebra Cut, which is 3 ft. higher. It would not be at all necessary to raise the entire floor in order to protect the lower one, should it be thought desirable to do so. Mr. Barnes would probably have come to the same conclusion had he attempted to build the floor in the form of an invert, as he proposes.

H. F. Hodges,
Member and Asst. Chief Engineer, I. C. C.,
M. Am. Soc. C. E.

Culebra, Canal Zone, Nov. 20, 1909.

Simplifications of Two Railway Curve Problems.

Sir: In your issue of Sept. 30, 1909, Mr. Wm. Clyde Willard contributes an article entitled "The Application of the Traverse Method to Railroad Curve Problems." In that article, Figs. 1 and 2, as he states, really represent the same problem. This problem is of use in rough, bluffy country where accurate measurement is difficult, when a change in the original location is desired. It saves time and gives more accurate results to join two circles lying close together on the ground by a tangent, rather than to turn tangent off one circle and run the tangent to intersection and entirely re-run the other circle over broken country.

The solution of this problem as given in the above-mentioned article follows the same method as that given in Nagle's Field Manual for Railroad Engineers.

The method below I have used several times; it will be found more suited to use in the field, since much less calculations are involved than by the traverse method, and the solution is in formula form.

The nature of the problem, a re-joining of a previously continuous line, supposes that the angular relation of any tangent to one circle to any tangent to the other circle is known. If this relation is not known, any hubbed line whatever (without measurement) joining the circles determines it. Then, in Figs. 1 and 2, herewith, let B be a hub on circle 2, with calculated course of tangent $B\,V$ known. Set hub at C on circle 1, so that tangent $C\,M$ is parallel to $B\,V$. Along $C\,M$ measure to some point H from which B is visible. Set hub at H, measure angle A and measure $H\,B$, which call K. Then $H\,E$ or $f = K \cos A$ and $B\,E$ or $d = K \sin A$.

In Fig. 1, $O_2\,N = R_1 + R_2 + d$, if $B\,V$ intersects circle 1, then $O_2\,N = R_1 + R_2 - d$; also $O_1\,T = R_1 + R_2$. In Fig. 2, $O_2\,N = R_1 - R_2 + d$, or if $B\,V$ intersects circle 1, then $O_2\,N = R_2 - R_1 - d$; also $O_1\,T = R_1 - R_2$. In both Figs. 1 and 2, if the measured distance $C\,H$ be called Q,

$$O_1\,N = Q + f;\ \tan y = \frac{O_2\,N}{O_1\,N};$$

$$O_1\,O_2 = O_1\,N \sec y \text{ or better } O_1\,O_2 = \sqrt{\overline{O_1\,N}^2 + \overline{O_2\,N}^2};$$

$$\text{Cos } x = \frac{O_1\,T}{O_1\,O_2} \text{ and } O_2\,T = m\,e = t = O_1\,O_2 \sin x$$

$$= \sqrt{\overline{O_1\,O_2}^2 - \overline{O_1\,T}^2}$$

The required angle of arc $m\,C$ or $B\,e$ is $x = y + z - 90°$.

In short, by taking the main auxiliary line tangent to one circle and parallel to a tangent at a given chosen point on the other circle, only two sides of a single right-angle triangle $H\,E\,B$ have to be calculated instead of the sides of the several right-angle triangles [latitude and departure of the several courses] by the traverse method. In other words, $f = K \cos A$ and $d = K \sin A$ by this method stands for all the traverse calculations by the other; for the rest the methods are identical.

Recently Fig. 1 came up as an office problem. All the traverse data of the plotted line were at hand, and as the line was plotted by coordinating the centers of circles instead of the P. I.'s of the tangents, the work was much simplified. The length and bearing of $O_1\,O_2$ was obtained directly from the worked-up tabulated traverse data. Since the bearing of O_1O_2 was referred to the map meridian, it was immediately known at what stations $O_1\,O_2$ intersected the circles, so that it was only necessary to calculate angle z, from $\cos z = \frac{R_1 + R_2}{O_1\,O_2}$, to find the station numbers of the tangent points m and e.

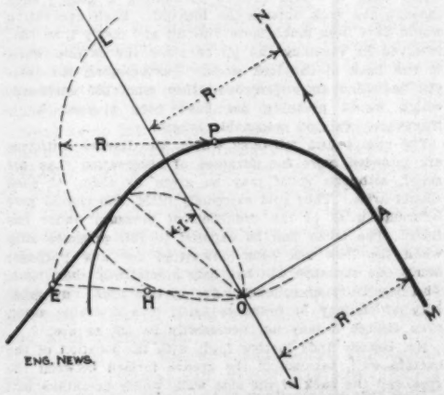


Fig. 3. From Fixed Tangent, Passing a Given Curve Through Fixed Point and Final Tangent Through Another Fixed Point.

The graphic-geometrical solution of this problem is apparent from inspection of the figures. Point T is at the intersection of arcs of circles of radii $\frac{1}{2}\,O_1\,O_2$ and $R_1 \pm R_2$, and with centers at p (a point midway between O_1 and O_2) and at O_1. Where $O_1\,T$ cuts circle 1 is point m, and where a parallel to $O_1\,T$ through O_2 cuts circle 2 is point e. This graphic method can be used to advantage when, having set m, it is intended to run the tangent to intersection and re-run circle 2. When the circles are considerably apart, then by whatever method the tangent has been determined, it should be run to intersection and circle 2 re-run to make a clean job.

Circle through Fixed Point.—In Fig. 3, Mr. Willard's other problem, it is not vital if points P and E are missed a few centimeters of inches. Therefore the following easy graphic solution gives a sufficiently close result.

Let $M\,N$ be the initial tangent on ground, with station enumeration in direction indicated by arrow.

P = fixed point through which circle is to pass.
E = fixed point through which final tangent is to pass.
R = radius of circle.

Draw $L\,V$ parallel to and distant R from $L\,M$. With center P and radius R describe arc of circle cutting $L\,V$ in O and L. Point O is the center of the required circle; L would be the required center of circle if direction of arrow were reversed. Erecting perpendicular $O\,A$ to $M\,N$ fixes $P.\,C.$ at A. Scale $M\,A$ and set the $P.C.$ Draw $E\,O$ and from its middle point H with radius $E\,H = O\,H$ describe arc cutting the main curve in K. Join $O\,K$ and measure angle I; then total angle of circle, for this figure, is $90° + I$.

O. G. Bunsen.
Locating Engr., Ferrocarril, Mexicano.
Cordoba, Eclo. Vera Cruz, Mexico.

Notes and Queries.

"Inquirer" asks for a definition of the difference between a bridge and a culvert. The best definition that we can make is to say that it is analogous to the difference between a dog and a puppy. There are bridges that are undoubtedly bridges, and culverts that are undoubtedly culverts, but we do not see how anyone can draw a hard and fast line at the point where a large-span arch culvert becomes an arch bridge. If anybody has anywhere succeeded in drawing such a line, we should be glad to hear from him.

W. J. D., Dauphin Co., Pennsylvania, writes:

As the use of the stadia is becoming more and more common, I think surveying chains ought to be graduated in tenths of feet.

He also inquires whether any engineers have used chains so graduated, in town surveying.

L. E. L., Juniper, N. C., asks for suggestions as to mounting maps on cloth. We know of no better way than the old plan of stretching the cloth on a large drawing-board, coating it well with paste, and laying down the map upon the cloth thus prepared. The ordinary stationer's paste is satisfactory for this purpose, although if much work is to be done it is much cheaper to make starch paste, adding some antiseptic to prevent molding.

The Report of a British Engineer on the Waterways of Continental Europe.

In view of the present tumultuous agitation for the investment by the Government of some hundreds of millions of dollars in waterway improvements, it is instructive to note that a very similar agitation has been going on for a dozen years in Great Britain. There, as here, it has been claimed that traffic on waterways has been destroyed by the railways to the great detriment of the public.

The result of this agitation was the creation, some time ago, of a Royal Commission on Canals and Waterways. This body, with the aid of experts, has been investigating not only the situation in Great Britain but foreign practice in waterway development as well. A stock argument of American waterway promoters is the extensive traffic on inland waterways in Continental Europe. There has just been published in England a report on European waterways, prepared by Mr. W. H. Lindley, M. Inst. C. E., for the Royal Commission. A review and summary of this report appears in London "Engineering" of Nov. 5. We reprint the major portion of this from our contemporary as follows:

"Undoubtedly the report on European waterways and canals drawn up by Mr. W. H. Lindley, M. Inst. C. E., for the Royal Commission on Canals and Waterways,

constitutes one of the most valuable and comprehensive of the Blue Books issued in recent years. The choice of Mr. Lindley as Assistant-Commissioner to collect the multifarious data here assembled was particularly happy. His reputation as a most able and enterprising engineer is international, and his long connection with the Continent has had, as one consequence, the result that many of the engineers responsible for the construction and maintenance of the great Continental waterways and canals are numbered amongst his personal acquaintances. This has, no doubt, been no small advantage to him in his arduous investigation.

The net result of the inquiry more than confirms the view expressed some years ago to a committee of the American Senate by Senator Hill—viz., that no artificial canal can begin to compete in freight charges with a railway built and operated for goods traffic only.

In no one of the European countries considered in Mr. Lindley's report are the canals self-supporting. In Belgium the State pays nearly 40% of the total freight by canal, and in France it pays 41%. This is, of course, very convenient for the trader, but somewhat burdensome to the rest of the community.

In Germany the waterways make a less unfavorable showing, and on the great rivers, such as the Rhine and Elbe, where there are many hundred miles of free navigation, the freight charges are often extremely low. Where, as in Germany, such rivers exist, capable, without betterment, of accommodating over long lengths barges, each carrying 400 or 600 tons, it may well prove profitable to construct canals connecting together these waterways, even if the artificial portions of the route are costly and relatively inefficient. Such interconnections avoid the breaking of bulk and all incidental transhipment charges.

Unfortunately, however, the manufacturing districts of Great Britain are, in general, not traversed by rivers capable in their natural condition of accommodating barges of reasonable size, and the canalization of such rivers is commonly a very expensive undertaking. The conditions here, therefore, compare much better with those which obtain in France than with those in Germany, though, on the whole, the situation is less favorable here than across the Channel.

The distinction between France and Germany in the extent of natural facilities for water-borne traffic is clearly set forth in Mr. Lindley's report. He points out that of the French waterways capable of accommodating modern barges, but 796 miles are "free" rivers, 970 miles are canalized rivers, and 1,706 miles are canals. In Germany, of similar waterways, no less than 1,948 miles of navigation are free rivers, 425 miles canalized rivers, and 895 miles canals.

In France the standard barge is 126 ft. long by 16.4 ft. broad by 5.9 ft. draft, and it carries 300 tons. The locks to accommodate these barges are 19.7 ft. wide and 133 ft. long if single, and 280 ft. if tandem. The depth over the sill varies from 8.2 ft. to 9.85 ft. In Germany there are two standard barges. The smaller, carrying 400 tons, is 180 ft. long by 26.25 ft. broad by 4.6 ft. draft; the larger, holding 600 tons, measures 213 ft. by 26.25 ft. by 5.75 ft. The locks are 31.5 ft. wide by 186 ft. or 220 ft. long, with a depth of 8.2 ft. to 9.85 ft. over the sills.

The canals to accommodate the standard barges have in France a cross-section 70 ft. wide at the water-line and 33 ft. wide at the bottom, the depth being 8.2 ft. to 9.85 ft. In Germany the standard canal is somewhat larger. Those designed for the 400-ton barges are 92 ft. wide at the water-line, and have a cross-section five times that of the barges traversing them. For the 600-ton barges the canals have a width of 102 ft. on the water-line, diminishing to 52.5 ft. at the bottom, the depth being 8.2 ft.

In France the average cost of the canals has been 19,700*l.* ($95,700) per mile, and the expenditure on canalized rivers has often been nearly as much. The canalization of the Seine, for instance, has cost 18,100*l.* ($88,000) per mile, whilst the minimum figure, even for small rivers under favorable conditions, is stated to be 5,470*l.* ($26,500) per mile. The whole of these waterways are now open to the public without dues, and the charges, falling accordingly on the general tax-payer, average 0.21d. (0.42 ct.) per ton-mile on the traffic, plus some indeterminate amount more for the engineering staff. The average freight charged on the waterways varies considerably, amounting on certain parts of the Rhone to no less than 0.93d. (1.86 cts) per ton-mile, while some down-stream cargoes on the Seine pay sometimes no more than 0.13d. (0.26 ct.) per mile. As a general average Mr. Lindley gives 0.289d. (0.578 ct.) per ton-mile as the freight by water, to which should be added a sum of 0.21d. (0.42 ct.) borne by the State, in order to get the true freight, which thus works out to at least ½d. (1 ct.) per ton-mile. The average rate by rail in France is 0.589d. (1.178 ct.) per ton-mile, but here again there is a Government subvention in the nature of guaranteed interest, which, if wholly attributed to the goods traffic, averages 0.16d. (0.32 ct.) per ton-mile, making the total rail charge 0.725d. (1.45 cts.) per ton-mile. This, however, is not really an equitable comparison, since canals, having to hug the contour lines of the map more closely than a railway need, are considerably longer between competitive points. In France, Mr. Lindley states, the average distance by canal is 60% more than by rail.

It does not, of course, follow because the average distance between competitive points is 60% more by canal than by rail that the bulk of the water-borne traffic actually travels this greater distance, since, presumably, the heaviest traffic will be along the most direct routes; and, perhaps, a 20% greater haul would better represent the difference between rail and waterway. The comparative total charges between the two would thus work out in the ratio of 0.725d. (6.45 cts.) by rail as compared with 0.600d. (1.20 cts.) by water. The advantage shown by the latter is, nevertheless, apparent only since the Government insist that between competitive points the railways shall allow the canals a differential advantage, which, Mr. Lindley states, is commonly 20%.

Even as matters stand, however, the apparent advantage claimed for the canal is arrived at by attributing the subvention of the State to the railways solely to the goods traffic. This is doubly unfair. In the first place, the railways are, as stated, not allowed to compete in rates with the canals; if they were, they would probably be able to greatly augment their returns; but, also, there can be no question whatever that a line built, like the canals, to handle goods traffic only could be constructed so cheaply as to require no aid from the State. This aspect of the question seems particularly important in this country. If it is a question of providing new canals, or of improving existing ones, it will in most cases be found cheaper to construct, instead of a canal, a mineral and goods railway, carrying no passenger traffic. Such a single-track line could handle more traffic than any canal commercially conceivable. It would necessitate the acquirement of much less land, could follow the *relief du sol* very much more closely, would be shorter, and could cross most roads on the level, which is, of course, an impossibility in the case of a canal. With a speed limited to 10 miles an hour, little expense in the matter of signalling arrangements would be necessary. On the French canals the speed of transit is only 1.67 miles per hour, but on the larger German canals it is 2½ to 3 miles per hour.

As to upkeep, the cost on the French canals is put down at only 75*l.* to 80*l.* ($400) per mile per annum, but to effect the requisite repairs it is necessary to close the canal temporarily every other year. Floods and ice also cause interruptions, and the total number of days in which a canal is out of service for these various reasons amounts sometimes to as much as 74 days in the year. Where the stoppage is necessitated for the purpose of repairs, the interruption, Mr. Lindley states, is limited, if possible, to between 15 and 20 days. With a railway, of course, repairs and replacements are easily effected without interruption to the traffic.

As already mentioned, water-borne traffic in Germany compares much better with rail-borne than in France. On the long stretches of navigable rivers, freights are exceedingly low, an average figure for coal being 0.187d. (0.374 ct.) per ton-mile. The corresponding figure by rail is 0.43d (0.86 ct.) but the water route is 20% longer. Even on these rivers, it should be noted that a capital expenditure of over 6000*l.* ($30,000) per mile has been necessary to fit them for traffic.

Owing to the large size of the barges, canal construction has been very expensive in Germany. The Elbe-Trave Canal has cost 27,500*l.* ($133,000) per mile, whilst the Teltow Canal has cost no less than 78,000*l.* ($379,000) per mile, plus an additional 7600*l.* ($37,000) per mile for the electric towage equipment. Fortunately, the very great length of the navigable streams goes far to offset the high cost of canal construction, so that total freights by water average about one-half of those by rail. The railways being, however, under State management, are, of course, not operated with the highest efficiency. Moreover, they show a surplus in working of 34,048,000*l.* per annum ($165,000,000) per annum, whilst the waterways involve a charge on the State of 1,391,000*l.* ($6,750,000) per annum, which is equivalent to 0.04d. (0.08 ct.) per ton-mile transported. This low figure is, however, due to the great length of the naturally navigable rivers, and if the loss be attributed, as seems fairer, to the canals and canalized rivers, it amounts to 0.10d. (0.2 ct.) per ton-mile.

The net result which appears to stand forth from Mr. Lindley's report seems to be that if traders here require lower freights, they should seek these by persuading Parliament to facilitate the construction of lines reserved exclusively for goods traffic, rather than in the extension and development of existing waterways. On the other hand, though the railway is the solution dictated by economical considerations, it is quite possible that Parliament may feel that the development of the canals may appear less obviously unfair to the existing lines; though if the State means to cook the goose of the latter, the precise nature of the accompanying sauce can hardly be a matter of much moment.

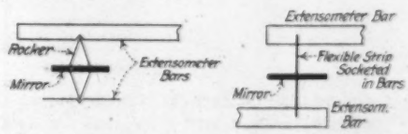
An abstract of Mr. Lindley's report is also given in "The Engineer" (London) which summarizes his averages of freight rates in Germany as follows:

Class of goods.	Railway. Average haul, miles.	Railway. Freight per ton-mile, cts.	Waterway or combined waterway and short rail freight. Average haul, miles.	Waterway or combined waterway and short rail freight. Freight per ton-mile, cts.
Coal	214	.86	257	.37
Iron ore, etc.	262	.96	324	.41
Corn and rice	241	1.60	285	.46
Sugar for export	149	1.04	199	.52

An Improved Mirror Extensometer.

Prof. B. Kirsch, of Vienna, Austria, has devised a simple but effective improvement in the favorably-known mirror extensometer. Such extensometers have become most widely known through Prof. A. Martens, of the Berlin Royal testing laboratory, and his modification of it is much used in Europe for delicate work.

In the mirror extensometer the two gage-points on the test-piece form each the attachment of a longitudinal bar, so disposed that the two bars lap past each other. When the test-piece is stretched, the gage-points move farther apart, and this will evidently appear as a relative sliding of one bar past the other, which rotates a small mirror; measuring this rotation by the reflection method, using scale and telescope, gives a delicate reading of the elongation. In the Martens form, a little transverse lever or rocker is interposed between the two bars, resting in a shallow groove or notch in each. This rocker carries the mirror. When the two bars move past each other, the rocker is rotated. The sensibility of the extensometer is obviously increased by shortening the length of the rocker, so that by using a very short rocker, resting in very fine transverse grooves in the extensometer bars, the instrument is made highly sensitive.



Martens' Rocker Lever. Kirsch's Flexible Spring Lever.

Kirsch's Improvement of the Mirror Extensometer.

The action is the same as when a needle is rolled between two strips that lap past each other; a very small relative motion of the strips will show us a large rotation of the needle. The needle arrangement has in fact been used for extensometers, the extensometer of J. B. Johnson being on this principle. But with a frictional rolling contact there is always the possibility of slipping, which would give false indications. The Martens rocker resting in transverse scratch marks (which act as sockets) is free from the fault of slip. But it is awkward to use and much subject to derangement. Handling and placing the small rocker is delicate work.

These disadvantages are largely removed by Prof. Kirsch's improvement, which recommends itself highly, since it makes the mirror extensometer much more practical, in fact even adapted to routine testing. Prof. Kirsch replaces the rocker by a thin, very flexible strip of spring steel, socketed in transverse slots in the faces of the extensometer bars. This strip, instead of tilting as does the Martens rocker, bends into an S shape when the bars move past each other. The slope of the middle part of this curve is measured by the rotation of a mirror attached here. It is clear that this angle of slope increases in linear ratio with the relative motion of the extensometer bars; i. e., if the mirror rotates twice as great an angle in one case as in another, the elongations being measured are also in the ratio 2:1. The sketch herewith illustrates the principle of the flexible spring connection so clearly as to require no further description.

With suitable design, this principle of construction results in an extensometer that is sub-

stantially a one-piece, self-contained instrument. Liability to derangement is therefore almost eliminated. With suitable stops and guard clamps or screws to take all duty off the springs except when the instrument is in place ready for use, full portability is attained, and the manipulation is rendered simple, quick and non-delicate.

Prof. Kirsch described his instrument recently before the Copenhagen congress of the International Association for Testing Materials.

Dry Rot the Cause of Collapse of a Factory Building During a Fire.

By IRA H. WOOLSON,* M. Am. Soc. M. E.

A few days after the destruction by fire of the Gledhill Wall Paper Factory at 541 West 34th St., New York City, the writer, while examining the ruins in company with Chief Beggin, of the City Fire Department, was informed by him that the fire which began about 3 o'clock in the afternoon was under control at 6 o'clock and at that time the floors were practically all in place, although the roof had fallen early in the fire. He further stated that shortly after the fire was under control the floors began to fall in irregular sections, and within two or three hours the whole floor system of the large building had fallen in a tangled mass to the basement. The reason of this collapse was not clear and the writer decided to investigate the cause.

The building had six floors and a basement with a frontage of 75 ft. on 34th St. and 50 ft. on 35th St., the depth from street to street being 200 ft. It was 18 years old and of peculiar construction. The first bay of each floor next the street at either end had cast-iron columns and steel I-beam floor girders. All the remainder of the building was of heavy timber framing such as would be used in standard slow-burning mill construction, but the floors, roof and other features of the building were in no sense slow-burning. In fact the numerous unprotected floor openings, and liberal use of light pine wainscoting, etc., together with the inflammable nature of its contents rendered the building peculiarly suited to the rapid hot fire which occurred, and this condition was aided by the early failure of the roof. The posts of the three lower floors were of white oak and the girders of long-leaf yellow-pine. In the three upper floors the posts as well as girders were long-leaf yellow-pine. The oak posts in the basement were 16 ins. square, and the others varied from 15 ins. on the first floor to 10 ins. on the sixth floor, all set on 12-ft. centers. The girders on all floors were 12 × 14 ins. square. The floor joists were 3 × 14 ins., set on 16-in. centers. On these was laid 1¼ × 3½-in. flooring, all of first class long-leaf yellow-pine. The posts and girders were joined by very heavy cast-iron post caps with 4-in. sockets above and below for the posts, and overhanging brackets for the girders to rest upon. For additional stability the posts were secured to the caps by four heavy lag-screws at top and bottom through the sides of the sockets, and the girders were tied at the ends by heavy iron straps spiked on.

By all the rules of slow-burning mill construction, this heavy timber framework should not have been seriously injured so far as strength or stability were concerned, even though the light flooring was burned out more or less. The only exception to this conclusion would be in the top floor where the framing was comparatively light weight, and the early collapse of the roof, together with the difficulty of reaching it by water contributed to producing a very hot fire. Nevertheless, the testimony of the firemen was that the floors began to fall almost before the fire was under control, and a few hours later the whole structure was in collapse.

A careful inspection of the wreckage removed the mystery. It was clear case of failure by dry rot in the timber posts. Many of the 14 and 15-in. oak posts were completely burned off at the upper ends under the caps. Usually about 12 to 18 ins. was thus burned off, though in some cases 2 to 3 ft. would be practically gone, and in one instance 5 ft. of a 15-in. post was burned off.

The remaining portions of these posts were sound and in prime condition excepting a char of ½-in. to 1 in. in depth, which would scarcely have injured their strength.

An examination of the three accompanying figures will give a clear idea of the condition described. Fig. 1 gives a general view of the wreckage in the narrow part of the building looking towards 35th St., the numbers 1 to 6 on the figure mark a series of 14-in. posts where the dry rot in the ends has been burned out, leaving the rest of the posts in good condition. The posts marked 1 to 4 were a continuous row of second-floor posts, while 5 and 6 mark third-floor posts; the latter is still standing amidst the wreckage. Eight out of ten 15-in. first floor posts directly under these shown in Fig. 1 were likewise burned off, most of them completely. Fig. 2 shows one that is partially gone. The numbers 7 and 8 on Fig. 3 mark two 15-in. first-floor posts in the front portion of the building which are completely burned off. The general character of the metal framed bays at the ends of the building can also be seen from these views. As previously stated, these were protected by water which doubtless accounts for their still remaining standing.

It is a peculiar fact, that of the 25 posts thus far found which have failed from the cause mentioned, all have burned off at the upper end. A few show a partial burn at the bottom, and a

FIG. 1. VIEW OF WRECKAGE AFTER FIRE AND COLLAPSE OF BUILDING. (14-in. posts numbered.)

FIG. 2. TOP OF 15-IN. POST, SHOWING INTERIOR HOLE BURNED OUT.

*Adjunct Professor Civil Engineering, Columbia University, New York City.

few, from which the iron caps were knocked off in falling but are not burned, show well rotted dry punk wood at the center, but in no instance was this rotting at the bottom nearly so serious as at the top. No satisfactory reason for this excess of decay at the top has yet been found. Another interesting fact is that the yellow-pine posts were in much better condition than the oak posts. Thus far only four pine posts have been found burned off, and evidence of rot in the ends of the pine girders is slight. A few have been attacked, but none have been discovered that were in a serious condition at this time.

None of the 16-in. basement posts are now accessible, so it is not known whether they are burned or not. They will be an interesting study when the debris is removed.

It is evident that the *final* collapse of this framework was due to burning out of the dry punk wood produced by dry rot in the posts, and it is very probable that *initial* failure resulted from the same cause. It is also quite possible that the same trouble produced the early collapse of the roof.

In the opinion of the writer this building was rapidly approaching a dangerous condition, even though no fire had occurred. The majority of

FIG. 3. SHOWING 15-IN. POSTS FROM FIRST FLOOR.

the heavy oak posts on the three lower floors must have retained but a small proportion of the strength they were supposed to possess. The outside shell at the top was all the sound wood that remained. The time must inevitably have come when a concentration of load on some floor due to stacking of stock or the movement of a large machine would have caused serious settlement and perhaps a collapse. The writer has never known a case of this kind before. An inquiry among insurance authorities of the city has not produced record of a similar instance, although it is probable that failures of this kind have occurred. Evidence on the subject may be secured from some of the insurance companies whose business covers the manufacturing plants of New England, where heavy timber construction is much more common than in this vicinity.

It is quite apparent that this subject is of vital interest to owners of this type of building, as well as to insurance companies who carry risks upon them.

Dry rot is a well known fungus disease of wood, which is sure to develop when green or wet timber is encased so that air may not circulate around it. Most building specifications require that the ends of wooden beams encased in walls shall have an air space around them to prevent dry rot. The rules of the Factory Mutual Insurance Companies of Boston specify that wooden posts shall have a 1⅛-in. hole bored through them and two ½-in. holes crosswise near the top and bottom to prevent checking. No mention is made of this provision being a preventive of dry rot, but it is quite certain that if the posts in this building had been thus bored they would not have rotted. The timber was doubtless only partially seasoned and the placing of the 4-in. socket caps upon it effectually excluded the air from the ends, giving the moisture no chance to escape. As a result dry rot developed, and had been slowly progressing until practically the whole cross-section of the posts had been reduced to a dry punk which could be broken by the fingers and would ignite from a match. The worst feature of this kind of decay lies in the fact that it proceeds from the interior, the outside seasoned shell of the timber giving no indication of the rottenness within. It is possible that the manufacture of paper in the building may have produced a moist atmosphere which aided the decay after it had once begun. Another interesting point in connection with the matter is that this condition has been brought about in a period of 18 years. It was about 25 years ago that the late Edward Atkinson began to advocate the merits of slow-burning mill construction in which heavy timber framing of this character was employed. A large number of factories and warehouses have been erected since that time of similar construction. It is important to know how many of them are getting into a dangerous condition by this slow method of deterioration. If the posts of such buildings have been bored as described above, they are probably in as perfect condition to-day as when installed, but, unfortunately, all building specifications have not made boring of posts a requisite, and where buildings were erected, as this one was, not conforming slow-burning construction, it is very likely this provision of post protection was seldom employed. The soundness of posts in such buildings to-day will depend upon their degree of dryness when installed, the snugness with which the caps fitted, as well as the atmospheric conditions of the building, whether dry or damp, and other things, such as painting, etc. It is well known that painting of timber before it is thoroughly seasoned is conducive to dry rot.

Fortunately the condition of such posts can easily be ascertained by boring a half-inch hole through them.

While yellow-pine will yield to dry rot under favorable surroundings, still it is not so susceptible to the disease as oak, and it is known that certain rot fungi will attack hardwoods and not attack resinous woods like pine. It may be that the yellow-pine timber in this building was less effected by the rot than the oak, because the particular fungus which caused the trouble would not thrive in pine, or it may have been much better seasoned than the oak. At least it is encouraging that the yellow-pine apparently resisted the disease best, for the day of oak construction is nearly gone, and the larger proportion of such constructions in the past 20 years has probably been of pine.

Depreciation Allowances on Equipment for Construction Work, U. S. Government Departments.

It requires little knowledge of either construction work or accounting to enable one to see that the real cost of constructing a building, a dam, or a harbor improvement work cannot be determined unless depreciation be taken into account. There are numerous ways of estimating depreciation, the relative value of which will depend upon the ultimate object in view.

The only branch of the U. S. Government which seems to have taken up the question of depreciation in systematic detail is the Reclamation Service. We need not consider here why this should be so, further than to state that the cost of the irrigation works built by the Service is to be collected from water users. For this and other reasons the Reclamation Service has elaborated a system of cost keeping rarely if ever equaled on public works, and as a part of that system careful account of depreciation is being taken.

The general method used by the Reclamation Service was outlined in a recent issue of the "Reclamation Record," as follows:

> The theory of depreciation charges is to load the output with the reduction in the value of equipment used. It is impossible to measure accurately the amount of this wear and tear or reduced valuation for each piece of work accomplished. The only way of determining accurately the amount of depreciation on any given piece of machinery or equipment is by its sale when the work is finished. The difference between the cost price and the amount realized by sale is the amount of depreciation. This method is, however, impracticable in the work of the Reclamation Service. It, therefore, becomes necessary to estimate the depreciation. There are two ways of doing this. The first and most accurate is to make a careful estimate periodically, say once each year, of the value of the equipment, taking into consideration its condition, both as to actual wear and tear from use and as to its obsolescence due to changing conditions, new inventions or new methods of doing the work. The other method of estimating depreciation is to determine the probable life of the machine or other equipment and assume a regular annual or monthly percentage of depreciation that will reduce the value to nothing at the assumed date of its becoming absolutely worthless.
>
> When depreciation is taken up with a debit to cost ledger features, the credit should be made to the inventory account representing the cost price of the equipment, provided the depreciation is a known or determined figure. If the depreciation is an estimate, however, it is not considered good bookkeeping to reduce the inventoried value by the amount estimated. In such cases the credit should be entered under balance sheet item, "Equipment Depreciation Account"; and when the depreciation is accurately known, either on sale of the equipment or on its being scrapped or inventoried, the amount entered as estimated depreciation should be eliminated by entries reducing the inventoried value and by adjusting entries in the cost ledger accounts taking up differences between actual and estimated depreciation. On large inventories containing a great many different items of equipment, the annual inventory, while an estimate, may be considered as representing actual depreciation for the purpose of making the proper adjusting entries.
>
> It is desired, therefore, that unless depreciation is actually known, the amount taken off monthly should be debited to cost ledger and credited to the equipment depreciation account, which will represent the estimated depreciation. The difference between the debit to the equipment inventory account and the credit to the equipment depreciation account will represent the estimated valuation of equipment on hand. Occasionally, preferably Dec. 31 of each year, a carefully considered revaluation of all equipment should be made, and this revaluation should be considered the actual value of equipment on hand. Adjusting entries should then be made so as to offset the equipment depreciation account and to adjust the depreciation debits to cost ledger heretofore made.

These adjusting entries seem to be particularly confusing, and an illustration is therefore presented, as follows: Assume that equipment is purchased at a total expense of $10,000; that during the year an estimated depreciation of $25 monthly is entered in the books; and that at the end of the year a revaluation shows the equipment to be worth $9,000. The following statements summarize the entries that should appear in the general ledger accounts concerned, before the adjusting entries are made:

EQUIPMENT IN USE.

Dr.	Cr.
Cost of equipment...$10,000	

EQUIPMENT DEPRECIATION ACCOUNT.

Dr.	Cr.
	Estimated depreciation, 12 mos., at $25.... $300

COST LEDGER.

Dr.	Cr.
Depreciation estimate.... $300	

After the adjusting entries are made, the summary statements should appear as follows:

EQUIPMENT IN USE.

Dr.	Cr.
Cost of equipment...$10,000	Actual depreciation...$1,000

EQUIPMENT DEPRECIATION ACCOUNT.

Dr.	Cr.
Adjustment..... $300	Estimated depreciation 12 mos., at $25.... $300

(This suspense account is balanced.)

COST LEDGER.

Dr.	Cr.
Depreciation estimate.. $300	
Depreciation adjustment 700	
Total depreciation absorbed $1,000	

The revaluation in this case shows that the estimated depreciation is $700 short of the actual depreciation. Should the revaluation show that the estimated depreciation is in excess of the actual depreciation, the entries would be reversed, the object being to place in the cost ledger the actual depreciation, when known, and to offset the amount carried in the suspense account by a reduction of the book inventory value to the figures shown by the revised estimate to be correct.

The monthly entries during the succeeding year should be made in the same manner, with an adjustment at the end of the year based on another physical inventory and revaluation.

We have obtained through a correspondent a statement as to the practice of other branches of the government in the matter of depreciation charges, reading as follows:

I have made inquiry at the offices of the Isthmian Canal Commission, the Supervising Architect of the Treasury Department, the Office of Inspection and Repair of Electric Light Plants, Treasury Department, and of the Chief of Engineers, War Department. These seem to be all the offices in this city which carry on large construction work.

The Isthmian Canal Commission reports that they make no book account of depreciation, as they regard this of little value except upon transfer of machinery and do not propose to take account of depreciation until the end of construction of the Isthmian Canal.

The Supervising Architect reports that he keeps no account of depreciation, as his work is all done by contract. I asked if they did not have power plants in service until worn out and necessary to replace from which depreciation data could be compiled from records. He said that this was perhaps true, but that the work involved would be enormous and the value of the results questionable.

A similar report was made by the Bureau of Inspection of Electric Light Plants.

The Chief of Engineers stated that no account of current depreciation is kept and this is not determined except upon the transfer of machinery from one work to another. When originally installed on a project, its cost is charged to that project and when transferred to another an appraisal is made, the amount of which is credited to the work finished and charged to the work started.

The appraisal is made by the parties in charge of the different works, and if they do not agree, the matter is arbitrated by the superior officer having charge of both, which in some cases is the Chief of Engineers.

Two Boiler Feed Devices for Locomotives.

A very general trouble with locomotive boilers is defective circulation due to the manner in which the feed-water is introduced. The almost universal practice is to deliver the cold feed-water through check valves below the water level at the sides of the boiler. The tendency then is for the water to flow to the bottom of the boiler, circulating only very slowly and cooling the shell and tubes so as to cause leaks and other troubles due to irregular expansion and contraction. This not only affects the efficiency of the engine but results in expense and lost time for boiler repairs. This subject was discussed in our issue of July 12, 1906, at which time some suggested changes in the usual practice were mentioned. Two boiler feed devices which are designed to eliminate the troubles above noted and which are now in extensive use are described below.

THE SEDDON DEVICE (Fig. 1).—In this device, the boiler checks are placed above the highest water level, and each is connected to a short length of copper pipe which extends across the steam space. The end of the pipe is plugged and there are small perforations in the upper part through which the water is sprayed. Thus the cold feed-water is distributed in a finely divided state through the steam, and falls upon the surface of the body of water in the boiler; thus it cannot flow in a solid stream to the bottom. The check valves are placed at the first ring of the boiler barrel, next to the smokebox.

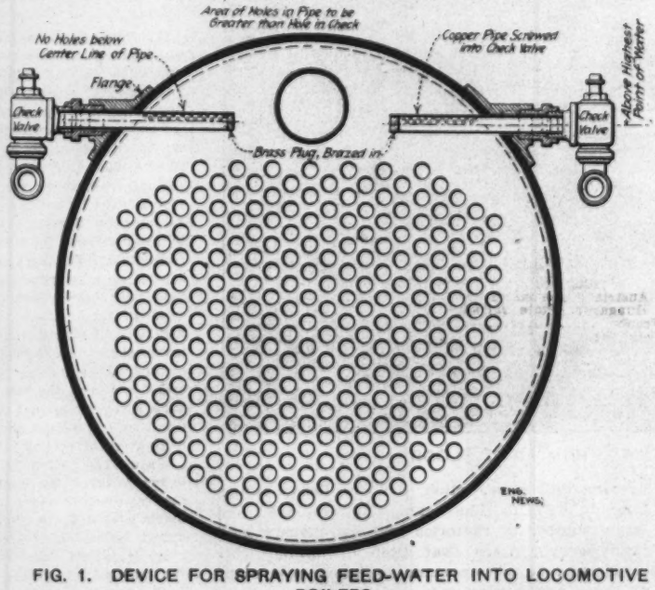

Area of Holes in Pipe to be Greater than Hole in Check
No Holes below Center Line of Pipe
Copper Pipe Screwed into Check Valve
Flange
Check Valve
Check Valve
Above Highest Point of Water
Brass Plug, Brazed in
ENG. NEWS.

FIG. 1. DEVICE FOR SPRAYING FEED-WATER INTO LOCOMOTIVE BOILERS.
(C. W. Seddon, Superintendent of Motive Power and Cars; Duluth, Missabe & Northern Ry., Inventor.)

This device has been invented and patented by Mr. C. W. Seddon, Superintendent of Motive Power and Cars of the Duluth, Missabe & Northern Ry., at Proctor, Minn. He informs us that it has been applied to practically all the engines of this road, and that after two years' service the results are shown to be as follows: (1) it has enabled train tonnage to be increased 10%; (2) the fuel consumption has been reduced 10%; (3) boiler failures on account of leaky tubes have been entirely eliminated; and (4) the work of the boilermakers in roundhouse running repairs has been reduced considerably. The device is being used experimentally by a number of other railways.

THE PHILLIPS DEVICE (Fig. 2).—In this device the two injector pipes are led to a single fitting bolted on top of the boiler shell. This has two independent check valve chambers, each controlled by an independent cut-off or stop valve inside the boiler. This makes it a simple matter to shut off one or both sides of the check for examining or adjusting the valves. The arrangement of the part inside the boiler is such that the entering feed-water is thrown out at the sides into the steam space and thus distributed over the surface of the body of hot water in the boiler.

This device has been invented and patented by Mr. C. Phillips, Master Mechanic of the New Orleans & Northwestern Ry. and Alabama & Vicksburg Ry. (Queen & Crescent Route), at Meridian, Miss. He informs us that there are now over a thousand of these boiler checks in use on the above roads and on other railways, principally in the south and southwest. The results in service and in tests have shown such strong evidence in favor of the double boiler check mounted on top of the boiler that they have led to the adoption of this device by the roads which have tried it.

Mr. Phillips states further that for several years he has advocated the admission of cold feed-water at the top of the boiler, as a means of improving the circulation and avoiding trouble due to irregular expansion and contraction of the boiler plates and tubes. It has been argued that this arrangement would cause scale to form rapidly on the upper tubes, but the reply to this is that the boiler feed should not be arranged to suit the quality of the water, but that water causing serious scaling should be treated before it is admitted to the boiler.

Mileages and Costs Per Mile of the Worlds' Railways.

The information contained in the following tables has been taken from tables compiled for the "Archiv für Eisenbahnwesen," and reprinted in the "Bulletin" of the International Railway Congress Association for September, 1909. In Table I., which gives data regarding mileages open on Dec. 31, 1907, the countries whose railways are listed, are arranged in five geographical groups: Europe, America, Asia, Africa and Australia. Table II., which gives construction costs per mile.

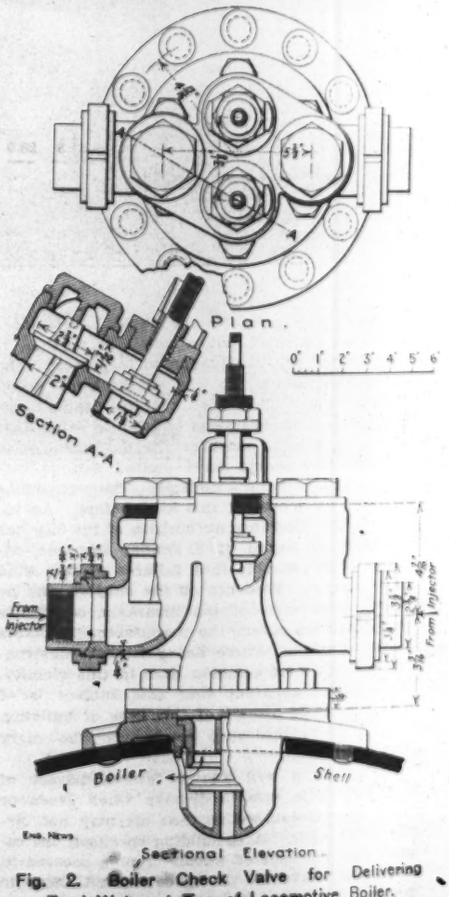


Fig. 2. Boiler Check Valve for Delivering Feed Water at Top of Locomotive Boiler.
(C. Phillips, Master Mechanic, Queen & Crescent Route, Inventor.)

TABLE I.—MILEAGE STATISTICS OF THE RAILWAYS OF THE WORLD.

Countries.	Mileage open Dec. 31, 1907.	Increase between 1903 and 1907, miles.	Mileage open at the end of 1907. Thousands of inhabitants in 1907.	Per 100 sq. miles.	Per 10,000 inhabitants.
1.—Europe.					
Germany	36,065	2,246	56,367	17.2	6.4
Austro-Hungary (inclusive of Bosnia and Herzegovina)	25,853	1,732	47,118	10.0	5.5
Great Britain and Ireland	23,084	623	41,450	19.0	5.6
France	29,716	1,616	38,962	14.2	7.6
Russia in Europe and Finland (2,057 miles)	36,279	3,186	105,542	1.8	3.4
Italy	10,313	346	32,475	9.3	3.2
Belgium	4,874	637	6,694	42.8	7.3
Netherlands and Luxemburg	2,230	135	5,341	15.0	3.9
Switzerland	2,763	188	3,325	17.2	8.3
Spain	9,228	621	17,961	4.8	5.2
Portugal	1,690	196	5,429	4.7	3.1
Denmark	2,141	178	2,449	14.3	8.7
Norway	1,677	150	2,221	1.3	7.2
Sweden	8,322	624	5,136	4.8	16.2
Servia	379	20	2,494	2.1	1.5
Roumania	1,995	21	5,913	3.2	3.4
Greece	771	128	2,434	3.1	3.2
Turkey in Europe, Bulgaria and Rumelia	1,968	16	9,824	1.9	2.0
Malta, Jersey, Isle of Man	68	....	372	16.1	1.9
Total for Europe	199,346	12,663	391,507	5.3	5.1
2.—America.					
Canada	22,448	3,374	5,339	0.6	42.1
United States of America, inclusive of Alaska (359.8 miles)	229,906	21,970	85,618	6.4	26.8
Newfoundland	906	11	214	1.6	51.1
Mexico	13,612	3,255	14,545	1.8	9.4
Cent. America: Guatemala (594.6 mi.), Honduras (57.2 mi.), Salvador (102.8 mi.), Nicaragua (171.5 mi.) Costa Rica (464.8 mi.)	1,392	446	....	...	...
Greater Antilles (Cuba, 1,775.3 mi.; Rep. of Dominica, 129.9 mi.; Hayti, 139.8 mi.; Jamaica, 185.2 mi.; Porto Rico, 200.0 mi.)	2,430	268	....	...	...
Lesser Antilles (Martinique, 139.2 mi.; Barbadoes, 108.8 mi.; Trinity, 88.2 mi.)	336	51	....	...	...
United States of Columbia	449	49	4,500	0.08	1.0
Venezuela	634	....	2,445	0.16	2.6
British Guiana	104	28	295	0.11	3.5
Dutch Guiana	37	37	....	...	...
Ecuador	186	....	1,400	0.16	1.3
Peru	1,332	297	4,607	0.82	2.9
Bolivia	702	46	2,269	0.16	3.1
United States of Brazil	10,714	1,346	14,934	0.32	7.1
Paraguay	157	....	636	0.16	2.5
Uruguay	1,211	....	931	1.8	13.0
Chili	2,989	54	3,314	1.0	8.9
Argentine Republic	13,673	2,237	4,894	1.3	28.0
Total for America	302,928	33,469	....	...	...
3.—Asia.					
Central Russia in Asia	2,808	1,150	7,740	1.3	3.6
Siberia and Manchuria	5,665	....	5,773	0.11	9.8
China	4,162	2,986	357,250	0.1	0.12
Corea	689	651	9,670	0.8	0.68
Japan	5,013	647	46,542	3.1	1.1
British India	29,892	2,942	294,906	1.4	1.0
Ceylon	562	170	3,687	2.3	1.6
Persia	34	....	9,000	0.005	0.04
Asia Minor, Syria and Arabia with Cyprus (36 mi.)	2,936	922	19,568	0.5	1.5
Portugese Indies	51	....	572	3.5	0.9
Malay Archipelago Borneo, Celebes, etc.)	636	236	719	1.9	8.8
Dutch Ind. (Java, Sumatra)	1,509	79	29,577	0.6	0.5
Siam	571	146	9,000	0.16	0.6
Cochin China, Camboja, Annam, Tonkin (1,490.1 mi.); Pondicherry (59 mi.), Malacca (57.2 mi.), Philippine Islands (153.8 mi.)	1,762	84	....	...	...
Total for Asia	56,284	9,963	....	...	...
4.—Australia.					
New Zealand	2,571	167	830	2.4	30.9
Victoria	3,428	45	1,201	3.9	28.5
New South Wales	3,471	333	1,370	1.1	25.4
South Australia	1,924	24	363	0.16	53.0
Queensland	3,405	477	485	0.5	70.2
Tasmania	620	....	172	2.4	36.0
West Australia	2,259	115	412	0.16	54.8
Hawaii (24.9 mi.) with the Isles Maui (6.8 mi.) and Oahu (56.5 mi.)	88	....	169	1.3	8.1
Total for Australia	17,766	1,161	4,942	0.6	35.9
5.—Africa.					
Egypt	3,445	492	9,833	1.0	3.5
Algiers and Tunis	3,049	7	6,695	0.8	4.5
Congo Free State	399	123	....	...	...
Abyssinia	192	80	....	...	...
British South Africa:					
Cape Colony	3,805	294	1,766	1.3	21.6
Natal	976	240	778	3.5	12.6
Transvaal	1,361	456	868	1.1	15.7
Orange Colony	886	385	208	1.8	42.6
Colonies:					
Germany (German East Africa, 254.8 mi.; German South West Africa, 689.7 mi.; Togo, 103.8 mi.; Cameroun, 99.42 mi.)	1,148	856	....	...	...
England (British East Africa, 583.5 mi.; Sierra Leone, 225.5 mi.; Gold Coast, 167.8 mi.; Lagos, 126.8 mi.; Mauritius, 131.7 mi.)	1,235	68	....	...	...
France (French Soudan, 883.0 mi.; French Somali Coast, 192.0 mi.; Madagascar, 92.6 mi.; Reunion, 78.9 mi.)	1,247	484	....	...	...
Italy (Erythrea, 71.5m.)	72	55	....	...	...
Portugal (Angola, 337.4 miles; Mozambique, 365.4 mi.)	703	86	....	...	...
Total for Africa	18,518	3,626	....	...	...
Recapitulation.					
Europe	199,346	12,663	391,507	5.3	5.1
America	302,928	33,469	....	...	...
Asia	56,284	9,963	....	...	...
Africa	18,518	3,626	....	...	...
Australia	17,766	1,161	4,942	0.6	35.9
Total for the world	594,842	60,882	....	...	...

is much less complete and there are only two groups, one for European railways and a second for those of all other countries.

Group 1 of Table I. gives the total mileage of the railways of Europe at the end of the year 1907, as 199,346. Of this total, more than 70% is in the five countries with the highest mileages: Russia, Germany, France, Austro-Hungary and Great Britain and Ireland. These five countries rank in the order named, Russia leading with a total of 36,279 miles. The next three in order of mileage, Italy, Spain and Sweden, have together a little less than 15% of the total for Europe. Therefore, it appears that 90% of the railway mileage of Europe is in the eight countries just named.

In increase of mileage between Dec. 31, 1903, and Dec. 31, 1907, Russia again heads the list and is followed by Germany, Austro-Hungary and France in the same order as for total mileage except that Austria and France have exchanged places. Great Britain is seventh, being surpassed by Belgium and Sweden and practically equalled by Spain. The increase in the four years covered is less than 3% of her total mileage at the end of 1903. Some explanation for this may be found in her notably high rate of mileage per unit of area which is higher than that of any other country of Europe, or of the world, except Belgium. Belgium's activity in railway construction is quite remarkable in view of her high mileage per 100 square miles of area (42.8). Her per cent. of increase (15%) is second, in Europe, only to that of Greece where there has been no gain in mileage since 1905. Belgium's gain has been by comparatively steady yearly increments. In Russia the yearly increment has steadily increased and this country, with its very low ratios of mileage to area and number of inhabitants, seems destined to be the principal field for future railway development in Europe.

In Group 2, Table I., it is found that of the Western Hemisphere's total mileage of 302,928, nearly 76% is in the United States. Canada is second with the Argentine Republic and Mexico closely contesting for third place. About 88% of the total mileage of North and South America is in the United States, Canada and Mexico. The mileage of the United States alone (229,905) is greater than that of all Europe by 30,560 miles and constitutes about 38% of the world's total. Her increase since 1903 (21,970 miles) is more than 6½ times that of Russia or Canada, her

TABLE II.—CONSTRUCTION COSTS OF RAILWAYS IN DIFFERENT COUNTRIES.

Countries and Railway Systems.	Time. To which the data as to the costs apply.	Mileage.	Construction capital. Total in millions of dollars.	Per mile.
1.—Europe.				
Germany:				
The entire system	1907	35,058	3,840	$108,500
Austro-Hungary:				
Austria: The entire system	1906	13,418	1,504	112,500
Hungary: State railways	1907	9,835	502	51,300
France	1905	28,973	3,520	122,000
Belgium:				
State railways	1906	2,505	431	172,900
Netherlands:				
The entire system	1897	1,653	138	83,500
Great Britain and Ireland:				
The entire system	1904	22,630	6,085	271,000
Denmark:				
State railways	1907-1908	1,194	60	50,300
Norway:				
The entire system	1907-1908	1,605	62	38,700
Sweden:				
The entire system	1905	7,834	2,500	32,100
Russia (without Finland):				
The entire system	1905	38,522	3,050	79,600
Finland: State railways	1907	1,899	67	35,200
Roumania:				
The entire system	1906-1907	1,977	171	87,100
Servia:				
State railways	1906	336	21	61,500
Bulgaria:				
State railways	1906	752	32	42,700
Italy:				
State railways	1906-1907	8,699	1,086	125,300
Switzerland:				
The entire system	1906	2,676	286	109,000
Spain:				
Northern railway	1905	2,287	224	98,800
Total and average	....	181,853	23,588	$130,000
2.—Other parts of the globe.				
United States of America	June 30, 1906	224,819	14,687	$68,800
Canada	June 30, 1907	22,447	1,296	58,000
Cuba	1905	1,534	66	43,100
Uruguay	1898-1899	997	53	53,400
Chili: State railways	Dec. 31, 1898	1,375	76	54,500
Argentine Republic	1906	12,776	645	51,000
British India	Dec. 31, 1907	29,892	1,311	44,100
Japan	March 31, 1907	4,807	217	45,540
Siam	1907-1908	236	11	29,200
Java	1893	607	30	52,600
Algiers and Tunis	Dec. 31, 1904	2,348	113	56,500
Cape Colony	Dec. 31, 1907	3,253	156	48,300
Natal	Dec. 31, 1907	976	67	73,300
Sierra-Leone	1903	222	5	20,800
Gold Coast	1903	170	9	49,600
Lagos	1903	125	4	34,200
Colonies:				
New Zealand	March 31, 1907	2,456	115	47,100
New South Wales	June 30, 1907	3,395	203	60,300
South Australia	June 30, 1907	3,452	219	63,500
Queensland	June 30, 1907	1,832	67	36,800
Tasmania	June 30, 1907	3,136	111	34,200
Western Australia	June 30, 1907	462	19	42,000
	June 30, 1907	1,763	5	30,200
Total and average		322,630	19,434	$60,400

nearest competitors, and constitutes about 36% of the total increase for the world.

Of the railway mileage of Asia (56,283 miles), more than 53% is in British India; in Africa, 73% of the total mileage is in Egypt, Algiers and Tunis and British South Africa; in Australia the mileage is fairly evenly distributed. The highest per cent. of increase in the world, according to the tables, is found in Corea, where the increase is 1,747% of the total mileage at the end of 1903. The 1907 mileage of Corea, however, is less than 700 miles. Persia, with only 33.6 miles of railway in its area of 635,160 square miles, has of all countries in the world much the lowest ratio of mileage to both area and population.

In Table II., Group 1, it is seen that the cost of construction of the British railways is more than 25% of the total for Europe and is more than one-third greater than that of the nearest European competitor, Germany. High cost per mile is a prevailing characteristic of the European railways. The average for Europe ($130,000 per mile) is approximately twice that for America. The highest cost per mile in the world ($271,000) is found in Great Britain, where it is nearly four times the figure for the railways of the United States. The total construction cost of the railways in this country, however, is more than twice the cost of those in the United Kingdom and is 62% of the total cost of all the railways of Europe.

A PATTERN EXPLODED IN A FOUNDRY in Germany some time ago, under the following unusual set of circumstances, described in "Stahl und Eisen" of Nov. 3, 1909: A large engine frame or bed, molded in the floor, was being cast. The mold had been dried by torches. Its cores were vented upward, except those of the shaft bearing, whose vents were lateral. In addition, deep vent-holes had been pricked in the sand all around the periphery of the mold at short intervals, say, 4 ins. apart. Alongside this mold and about 5 ft. away, a second mold of this frame was in preparation, and the frame pattern was in the sand; no cope was on it at the time. This pattern was substantially a long, hollow box, closed on all sides, about 22 ft. long by 2½ ft. wide and 4 ft. deep. About three hours after the finished mold was poured, some men were at work nearby filling a ladle with molten iron, and a drop of the iron was spattered out upon the top of the frame pattern lying in the unfinished mold. The pattern blew up violently, injuring five men, one fatally, and damaging the roof and breaking most of the windows of the foundry. It seems that the venting of the frame mold had not been sufficient to carry all gases off freely, and enough filtered through to the adjoining unfinished mold and through the joints of the pattern to fill its hollow interior with an explosive mixture. The same frame had been cast several times previously without accident, but after the explosion the top face of the pattern was provided with several large holes, to make impossible any accumulation of gas inside.

THE BOILER EXPLOSION IN THE PABST BREWery at Milwaukee, Wis., noted in our issue of Oct. 28, 1909, is ascribed by an article in "Power and the Engineer" of Nov. 23, 1909, to faulty design of the riveted joint at longitudinal seam of the drums. Both drums of each of three water-tube boilers exploded, making six drums in all, and every drum failed along the seam where the reinforcing strip was riveted to the shell. The reinforcing strips were of ⅝-in. steel riveted on the outside of the ⅜-in. sheets and were exposed to the hot gases of the furnace. The seams at which the drums failed had given trouble by leaking for some time previous to the accident. Some of the rivets had been replaced and an excessive amount of calking had been done in the effort to stop the leaking.

A Method of Constructing Reinforced-Concrete Cylindrical Storage Bins.

Cylindrical bins of reinforced-concrete have been built at the new rock crushing plant of the Dolese & Shepard Co., at Gary, Ill., for the storage of the various sizes of crushed stone. They are arranged in two groups of four and ten bins respectively, each group standing upon a rectangular slab of concrete supported by concrete columns and girders. This slab or floor is about 22 ft. above the ground, so that railway cars can be run underneath and loaded from the bins by openings in the slab. The bins are 20 ft. diameter inside and 33 ft. high; the walls are 8 ins. thick, or 12 ins. at the points of contact with adjacent bins and with the side walls of the building.

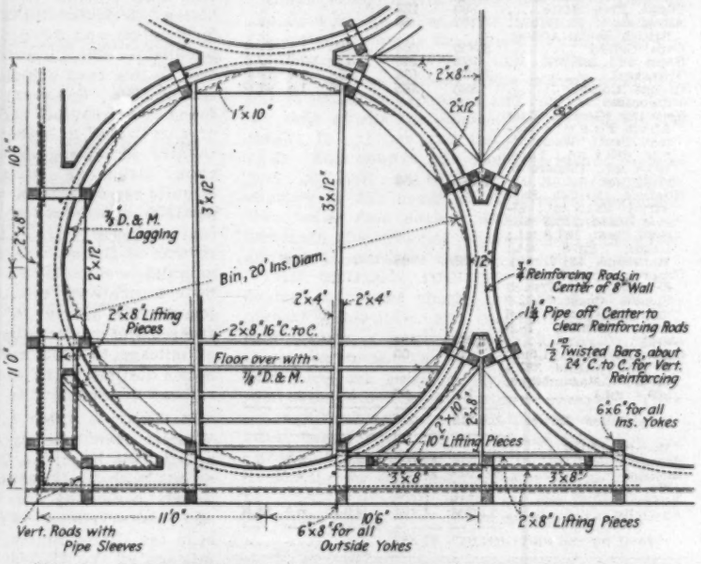


FIG. 1. FORM CONSTRUCTION FOR REINFORCED-CONCRETE BINS.

The storage buildings were erected by the Macdonald Engineering Co., of Chicago, and a special method was devised for the construction of the bins. The lower part of the structure being completed, the entire upper surface of the slab was covered with a wooden form about 3 ft. 6 ins. high. The only openings in this form were the spaces for the bin walls, giving the correct shape and thickness required for these walls. In these spaces were placed the steel reinforcing rods, both horizontal and vertical. At regular intervals on the circumference of the walls a vertical gas pipe was inserted. These pipes were built into the walls together with the reinforcing rods, and became the supports for the forms, the construction of which is shown in Fig. 1.

A specially constructed yoke spanned the wall space at each gas pipe, and united and held firmly the two portions of the form which formed the outer and inner surfaces of the walls. A jack mechanism connected each yoke with its vertical pipe, and the forms were raised slowly by this mechanism, as required, so that the process of molding or pouring the walls was carried on continuously day and night. The upward movement was conducted at such a speed as to allow the concrete at the bottom of the form to set hard enough to stand before being exposed.

The lifting jack, with its application to the moving form, is illustrated in Fig. 2. The walls of the form (A) (A) are spaced and connected by the yoke or frame (B). The jack mechanism is attached to the upper cross bar (C) between the timbers of the yoke. The mechanism consists of a short bell-crank lever (D), the upper pivot of which is connected directly to the cross bar of the yoke, and the lower pivot is connected to the sliding friction collar (E) by two links (F). The friction collar grips a central shaft (G), passing up through the center of the cross bars on the yoke; the lower end of this shaft rests on the gas pipe mentioned above. The pipe is in sections about 3 ft. long, and new sections are inserted in the concrete as the work progresses. The jacks are spaced about 8 ft. apart around the work.

In operation, the jacking lever is raised, thus raising the friction collar upwards. This reverse motion causes the collar to grip the shaft and the yoke to slide upwards on the shaft, thus raising the whole form and molding mechanism. The amount of this movement is about ¼-in. for each stroke. The cut shows the form partly filled with concrete, the upper portion being empty. In this space, the reinforcing material (not shown) is placed during construction. When the form has been raised to the top of the friction shaft, which for general practice is about 3 ft., the shaft is released and elevated high enough to allow a new section of the supporting pipe to be placed under it. The process is repeated until the wall is carried to the required height.

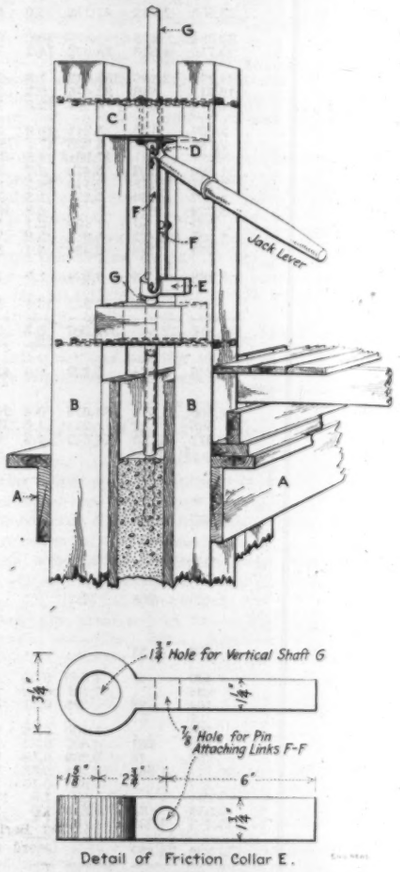


Fig. 2. Jacking Mechanism for Raising the Forms for Concrete Storage Bins.

The entire bin storage was in this way raised at the rate of 3¼ ft. per day during the chilly and wet month of November. It is estimated that at a more favorable time of the year, when the concrete will set faster, a rate of from 5 to 6 ft. per day could be maintained.

Notes from Engineering Schools.

STEVENS INSTITUTE.—The Stevens Engineering Society, which is affiliated with the American Society of Mechanical Engineers, has arranged an interesting program of popular lectures on engineering subjects for the season of 1909-10. The lectures are delivered at the Institute in Hoboken on each Tuesday afternoon, the lecture beginning at 4.10 p. m. and lasting one hour. The lectures are open to engineers who may be interested in the subjects, and a program of the lectures may be obtained by addressing the president of the Society, Mr. Hasbrouck Haynes.

THE RAILWAY ACCIDENT AT JERSEY CITY on the Pennsylvania R. R. Nov. 6 has been investigated by a committee of experts appointed by the railroad's General Manager. The report of this committee, signed by Mr. W. H. Elliott, Signal Engineer of the New York Central lines, ascribes the accident to a derangement of the mechanism of the combination board in the signal tower. As a consequence of this derangement, the cross-over switch from one track to the next remained open while the lever in the tower was in the closed position. Details of the accident were noted in our issue of Nov. 11.

THE ST. PAUL MINE AT CHERRY, ILL., has again been sealed in an effort to extinguish the fire started by the explosion of Nov. 13. On Nov. 24, the dead bodies of about 150 miners were found by a rescue party in the lowest level of the mine. It appeared that they had lived for perhaps 48 hours after the explosion and were then killed by black damp. It was not possible to remove the bodies from the mine because of the advance of the fire toward the shaft and because parts of the lowest level were flooded with water which had been poured in to extinguish the fire. On Nov. 25, it was decided to be unsafe to attempt further rescue work and both the main shaft and airshaft were sealed.

A TROLLEY CAR STRUCK AN AUTOMOBILE on the Los Angeles & Santa Ana Ry. Nov. 25, six miles from Los Angeles, Cal. Five of the seven occupants of the automobile were killed and the two others were severely injured.

A COAL MINE EXPLOSION at Onoura, Fukuoka Province, Japan, Nov. 25, entombed 220 miners. Reports state that 15 men are known to have been killed and that the fate of the others has not yet been determined.

An explosion in the Scott shaft at Shamokin, Pa., Nov. 27, severely burned seven miners, four of whom are not expected to recover. This mine is operated by the Susquehanna Coal Co.

A WORK TRAIN WAS WRECKED Nov. 28 on the Great Northern Ry. between Vancouver and New Westminster, B. C. The train consisted of a box car, coupled directly behind the locomotive, followed by a number of flat cars and a caboose. As the train was crossing an earth-fill over a culvert, the embankment, which was weakened by floods, gave way and dropped the box car into the stream, and the rest of the train piled up on top of it. About 20 Japanese laborers were killed.

A BREAK IN THE FLUME of the hydro-electric power plant of the Winnipeg (Manitoba) Electric Ry. on Nov. 23 flooded the power-house and tied up most of the electric light and power service of the city. At last reports the plant was still under water and the city was being partially served by an auxiliary steam power plant.

TWO GERMAN AERONAUTS, Hugo France, an architect, and Dr. Brenckmann, a surgeon, both of Berlin, were killed while trying to establish a new record for balloon travel. They ascended at Berlin on Nov. 22 and the wreck of their balloon was found near Fiume in Austria-Hungary, close by the Gulf of Quarnero on the Adriatic Sea. This is about 500 miles distant from Berlin, in an air line. The balloon envelope was rent and it is supposed that it had burst at a high altitude.

THE ANDES SUMMIT TUNNEL OF THE TRANS-Andine Railway connecting Chile with Argentine was holed through in the last week of November. The tunnel is about four miles long, is single-track, and is timbered on much of its length. It lies on the Chilean side of the international boundary, and is part of the work of the Transandine Construction Co., which, with the operating company (the Chilean Transandine Railway Co.) is owned by interests headed by Grace Bros. & Co., of London. The construction company sublet the tunnel work to Walker & Co. The tunnel will be finished with track probably by March, 1910, and this will complete the line.

THE WRECKAGE OF THE PEORIA BRIDGE will probably have to be removed by the federal government, as no bids from private concerns were received in answer to the advertisements noted in our issue of Nov. 4, 1909, p. 501. The city has made the necessary effort to comply with the order of the army engineers to remove the obstruction, and this effort having failed to bring any results, there seems to be nothing for the federal government to do but to superintend the removal itself and then collect, if possible, from the city.

THE LARGEST WOODEN VESSEL ever built in the United States is to be launched at Bath, Me., Dec. 14. This vessel, the "Wyoming," is a six-masted schooner 350 ft. long over all with a gross tonnage of 3,730. The schooner "William L. Douglas," the largest wooden vessel prior to the "Wyoming," has a gross tonnage of 3,708.

NEW BRIDGES OVER THE THAMES RIVER, at London (England), are proposed on account of the increasing density of the traffic and the congestion on the present bridges. The common council has approved a project for a new bridge near St. Paul's Cathedral, to cost $8,230,000; also for the widening of Southwark Bridge at a cost of $1,305,000. The widening of Blackfriars Bridge has been completed, but the traffic over it is still very dense, due to the street railway extensions. It is proposed that the new St. Paul's Bridge should be a double-deck structure, with street railway tracks on the elevated deck, and that an elevated structure for street cars should be built on the widened Southwark and Blackfriars bridges. The extension of these elevated structures for some distance beyond the bridges proper has been suggested, with a view of avoiding the concentration of traffic at the bridge ends. Other projects are for shallow subways for street railways across the busy parts of the city. As to the bridge traffic it is stated that before the opening of the Tower Bridge several years ago the number of vehicles crossing London Bridge was 22,000 daily. At the present time London Bridge carries 23,000, and the Tower Bridge (near by) carries 14,000, showing an increase of 15,000.

AN IMPORTANT COURT DECISION on the fixing of railway rates was rendered at Philadelphia Nov. 22 by the U. S. Circuit Court, made up of Judges Gray, Buffington and Lanning. The Court unanimously held that the fixing of railway rates is a non-judicial function, but appertains to the legislative branch of government. The Court further declared that when Congress has acted to fix rates, either directly or by proper delegation of its powers to the Interstate Commerce Commission, the orders of the Commission will not be suspended or vacated by a court unless some legal, constitutional or natural right has been violated.

THE U. S. RECLAMATION SERVICE should have its facilities to do work enlarged by a loan of $30,000,000, according to the recommendation of Secretary Ballinger in his annual report. Secretary Ballinger favors an urgent appeal to Congress to authorize the issuance of certificates of indebtedness or bonds, to be secured by the revenues of the Reclamation fund, in order that work may be pushed rapidly forward by the Reclamation Service upon the completion and extension of existing projects and the undertaking of such new works as will be necessary to make the adjustment required by law in 1912, between the various states in which the fund is expended.

WATER-POWER SITES ON THE PUBLIC LANDS still under public ownership should not be sold, but be leased for development, according to the recommendations of Secretary Ballinger in his annual report. His plan for such leasing is outlined in the following summary:

(1) That the title to such lands be reserved in the Federal Government, and only an easement granted for the purpose of developing and transmitting electrical power for private and public use, and for the storage of waters for power, irrigation, and other uses;

(2) That such easement be granted for a limited period, with a maximum of at least 30 years, and the option of renewal for stated periods upon agreed terms;

(3) That entry shall be accompanied by plans and specifications covering the works sought to be installed, and covering the maximum horse-power capable of development at such site; also, that a substantial entry fee be paid to show good faith, and that a transfer to the United States of the necessary water rights to permit of the estimated power development be made;

(4) That the construction period allowed entrymen for the development of at least 25% of such power shall not extend beyond four years, or such further time as may be granted by the Secretary of the Interior upon a proper showing;

(5) That a moderate charge shall be made on the capital invested, or upon the gross earnings of the project for the first ten years of operation, adjusted at each subsequent ten-year period, and equitably determined by appraisement;

(6) That all rights and easements shall be forfeitable for failure to make development within the limitations imposed or upon entry into any contract or combination to charge or fix rates beyond a reasonable profit on the investment and cost of operation, or entry into any agreement or combination to limit the suply of electrical current, or failure to operate the plant; and,

(7) That all books and accounts shall always be subject to the inspection of the department.

A CONCRETE ARCH BRIDGE WAS TAKEN DOWN recently in Germany. The bridge was built only eight years ago; it crossed a double-track railway line (between Weddau and Oberhausen) and was removed because the line had to be four-tracked. The span of the bridge was 56 ft., the rise 11 ft., and the width 24½ ft. The arch-ring, 16 ins. thick, was reinforced according to the Monier system with two layers of round rods in both directions, 9/16-in. circumferential rods 6 ins. apart and 5/16-in. longitudinal rods 24 ins. apart. It was removed by dynamiting it, the work being done by a detail of pioneers from the army. The explosive was placed on the arch ring at the crown (the filling having been cleaned off in preparation). The size of cartridge is stated as 3 × 2 × 1½ ins. Eleven groups of four cartridges each were placed 24 ins. apart in shallow recesses in the crown concrete, and two groups of eight against the spandrel walls, 60 in all. They were capped with earth and sod. The blast tore the structure apart at the crown, and the sides broke off at the springing; the fact that the spandrel walls failed to hold the sides up may be charged in part to the construction joints over the skewbacks. The debris, which blocked the tracks below, proved very difficult to reduce to pieces small enough to handle, and after 12 hrs. work only one track had been cleared. This work was done on Sunday. The abutments were blown up on two subsequent Sundays. (Zentralblatt der Bauverwaltung, Nov. 13, 1909.)

UNDERPINNING A SWING-BRIDGE CENTER PIER was carried out at Tehama, Cal., on the Southern Pacific Ry. during the past year. The upper part of the pier, 22 ft. in diameter and 22 ft. high, is stone, down to 2 ft. below low water; the base is of concrete, from 2 ft. below low water to about 13 ft. below low water, this latter being the river bottom. The pier rested on a pile foundation, the piles being driven some 10 to 12 ft. into the hard gravel river bottom, and projecting about 5 ft. up into the concrete. In the spring freshets of 1909, the bottom was scoured out on one side of the pier, so much that the piles on that side were exposed for 6 or 8 ft. Some settlement of the pier resulted therefrom, the top being tilted over to one side about an inch. It was decided to repair and strengthen the foundation by carrying the concrete pier base lower down and spreading it laterally. The operation proved relatively simple, according to Mr. J. Q. Barlow, Asst. Chief Engineer of the Southern Pacific Co. The river here is navigated ordinarily by but one boat, and the draw needs to be opened only about once a week; in low-water, moreover, navigation is often suspended for several months, until the fall rains. The draw-span could, therefore, be put out of commission without objection. It was wedged up on timbers resting on four clusters of piles driven for the purpose, thus taking the load off the pier. Then a cofferdam of two rows of sheet-piling enclosing a 6-ft. wall of clay was built around the pier and pumped out; a 6-in. pump readily controlled the flow. The soil under the pier was then dug out under one quarter, to a depth of 7 or 8 ft. below the old concrete and a distance of 4 to 6 ft. back under the pier, and the space filled with concrete; this new footing was carried out about 8 ft. from the line of the old base. The same procedure was then gone through for the rest of the circumference, section by section. The result is a new footing, 7 or 8 ft. deeper than the old base and 16 ft. larger in diameter, with a core of earth in the center extending up to the old base.

CANADA'S CEMENT MERGER.—According to the returns made to the Dominion Government by the cement manufacturers of Canada, the average price obtained by them at their works during 1908 was $1.39 per barrel. This was the lowest price ever reported by the Canadian mills. In 1906 the average price was from $1.65 to $1.70 and in 1907 about $1.60. At the beginning of the present year it was alleged by a number of manufacturers that even without any increases in price the business would be rendered more profitable by merging the large competing companies into one gigantic concern so as to be able to control the price and the output. The Canada Cement Co. is the result, with a capital of $30,000,000. The new company will own and control cement-producing plants at Montreal, Lakefield, Shallow Lake, Owen Sound, Calgary, Belleville, Hull, Maribank, Port Colborne, Exshaw, and Quebec. These localities include points from the St. Lawrence River to the Rocky Mountains.

The object of the merger is to eliminate the present excessive freight charges by distributing from the plant nearest the demand of the consumer, also to do without competitive salesmen and middlemen. The plants included in this combination are among the best constructed and most efficiently equipped in existence, with a capacity of 4,500,000 bbls. of Portland cement annually. During 1904 Canada manufactured 908,990 bbls. of Portland cement and consumed 1,694,968 bbls. Almost one-half, or 784,630 bbls. were imported. In 1908 the consumption was 3,134,338 bbls., and the output 3,495,961 bbls., while 469,849 bbls. were imported, which means that there was a surplus of 831,472 bbls. on hand at the beginning of the present year. This caused a general depression in the cement industry and a reduction in prices to such an extent that the most of the plants were closed for the time being.

Inasmuch as the capacity of the output of the merger is greater by a million barrels than the annual consumption, it would appear as though the aim of the company was not only to control the output, but the market of the Dominion.

Canada is rich in the raw material—marl, limestone, etc.—that enters into the manufacture of Portland cement. Promoters have taken advantage of these opportunities, and cement plants were organized all over the country during the past decade. The result is that the production is greater than the demand, and much money has been lost by the honest stockholders, for the promoter was not always too honest. The reorganization is not only to put the industry upon a paying basis, but to

aid as far as possible many localities where valuable cement plants are located and which are the main local industry.—United States Monthly Consular Reports, November, 1909.

Personals.

Mr. C. W. Stansberry has been appointed Master Mechanic of the Western Pacific Ry. at Elko, Nev.

Mr. Wm. F. Morse has opened an office as a consulting sanitary engineer at 111 Broadway, New York City.

Mr. Chas. E. Lenhart, Master Mechanic of the Buffalo & Lake Erie Traction Co., has resigned, effective Jan. 1.

Mr. C. H. Ketcham has been appointed Superintendent of the western division of the Western Pacific Ry. at Sacramento, Cal.

Mr. Geo. O. Chaney has been appointed City Engineer of Salt Lake City, Utah, to succeed Mr. Louis C. Kelsey, resigned.

Mr. Geo. S. McKee has resigned his position as Superintendent of Motive Power and Car Equipment of the Mobile & Ohio R. R.

Mr. W. C. Sawyer, Assoc. M. Am. Soc. C. E., has opened a salesroom at 429 West Seventh St., Los Angeles, Cal., where he will handle concrete machinery and technical publications.

Mr. J. W. Dean has been appointed Superintendent of the Colorado lines of the Denver & Rio Grande R. R. Mr. Dean was formerly Superintendent of Terminals of the Missouri Pacific Ry. at St. Louis, Mo.

Mr. G. Bremer Griffin has been appointed Manager of the detail and supply sales department of the Westinghouse Electric & Manufacturing Co. He has been Assistant Manager of this department for the past six years.

Mr. Robert J. Long, Assistant Manager of the Parral & Durango R. R., has been appointed General Manager to succeed Mr. James I. Long who has resigned to devote all his time to the Palmilla Milling Co., of which he is President.

Mr. E. J. Worden has been appointed Assistant Division Superintendent of the Chicago, Burlington & Quincy R. R., at Brookfield, Mo., to succeed Mr. R. M. Ogilvie, who has resigned to become Superintendent of the eastern division of the Western Pacific Ry. at Elko, Nev.

J. R. Finlay, M. Am. Inst. M. E., has been appointed General Manager of the Goldfield Consolidated Mines Co. to succeed Mr. J. H. Mackenzie. Mr. Mackenzie will continue to act as Consulting Engineer for the Goldfield Consolidated but will devote most of his attention to private interests.

Lieut.-Col. H. M. Chittenden, Engineer Corps, U. S. A., is to be promoted and retired, it is reported, upon the retirement of Col. John G. D. Knight, Jan. 24, 1910. Col. Chittenden's retirement will be for disability resulting from incident of service. His retirement for age would not occur until October, 1922.

Messrs. John W. Alvord, of Chicago; George W. Whipple, of New York, and Harrison P. Eddy, of Boston, have been appointed as a commission to advise the city of Milwaukee in regard to sewage-disposal problems. The appointment of Mr. Eddy for this purpose was noted in our issue of Nov. 18; the names of the others were inadvertently omitted.

Messrs. Leonard Metcalf, M. Am. Soc. C. E., of Boston, and John W. Alvord, M. Am. Soc. C. E., of Chicago, have been appointed by the Indianapolis Water Co. to appraise its property. The appraisal is being made in connection with the revision of the accounting system of the company and with particular reference to giving proper consideration to depreciation.

Mr. S. L. Nicholson, Assoc. Am. Inst. E. E., for the past five years industrial and power sales Manager of the Westinghouse Electric & Manufacturing Co., has been appointed General Sales Manager with direct charge over the sales policies of the entire company. Mr. Nicholson has been in the employ of the Westinghouse Electric & Manufacturing Co. in various capacities for eleven years.

Mr. Chas. Robbins, Assoc. Am. Inst. E. E., has been appointed Manager of the industrial and power sales department to succeed Mr. Nicholson.

Mr. Leonard M. Cox, Civil Engineer, U. S. Navy, recently on duty at the navy yard, New York City, has been appointed Assistant to the Chief of the Bureau of Yards and Docks, with office at Washington, D. C. Mr. F. R. Harris, Civil Engineer, U. S. N., recently on duty as Principal Assistant of the Chief of the Bureau of Yards and Docks, has been placed in charge of the construction of the new drydock at the navy yard, New York City.

Mr. Charles S. Price, General Manager of the Cambria Steel Co., Johnstown, Pa., will become President of that company in March, 1910, succeeding Mr. Powell Stackhouse, who is to retire from active business.

Mr. Price studied civil engineering at Cornell University, graduating in the class of 1872 at the age of 20 years. He was employed for a short time by the Detroit Bridge & Iron Works, Detroit, Mich., and then served for three years as City Engineer of Lock Haven, Pa. He first entered the service of the Cambria Steel Co. in 1876 as a draftsman in the engineering department at Johnstown, Pa. He supervised the details of construction of the first open-hearth steel plant erected by the company and three years later he became Superintendent of the open-hearth department. He was made Superintendent of the Bessemer open-hearth and blooming department in 1884, and in 1886 he was put in charge of the metallurgical department, organized in that year, which comprised the Bessemer and open-hearth steel works, rolling mills and blast furnaces. He became General Superintendent of Manufacture in 1890 and General Manager in March, 1892.

Mr. Stackhouse, who is 69 years old, entered the service of the Cambria Iron Co. at the close of the Civil War. He was at first in charge of the company's affiliated operations, such as the brickyard and woolen mill, and afterward served seven years as Assistant to the General Superintendent. He was in charge of mining operations for the Republic Iron Co. in northern Michigan for three years, but returned again to the Cambria Iron Co. in Philadelphia and became successively General Manager, Comptroller and Vice-President. He became President in 1891 upon the death of Mr. Edward Y. Townsend and, when the Cambria Steel Co. gained control of the property in 1898, he became President of that company.

Obituary.

H. C. Amsbary, Superintendent of the electric light plant at Wellsville, N. Y., died Nov. 25 as the result of a fall from a platform where he was at work. His fall was caused by a slight electric shock.

Albert V. Porter, an architect of New York City, died Nov. 23 at his home in Brooklyn, aged 53 years. He was formely Consulting Architect for the Manhattan Street Ry. Co. and was a fellow of the American Institute of Architects.

Alfred Strehler, a civil engineer and contractor of Cleveland, Ohio, died Nov. 25 at a hospital in that city. Mr. Strehler was born in Switzerland and studied civil engineering in the schools of that country and of Germany. He came to the United States in 1878 and was employed by a copper mining company in the Upper Peninsula of Michigan. In 1887 he went to Cleveland and became Assistant to the City Engineer, in charge of the department of surveys. He remained in the city engineering department until 1899, when he entered the contracting business. At the time of his death he was the senior member of the firm of Strehler & Tubman.

W. McLea Walbank, Past President of the Canadian Society of Civil Engineers, died Nov. 28 in the General Hospital, Montreal, Que. Mr. Walbank was born at St. Johns, Newfoundland, in 1856, and was educated in the schools of that place and in Queen's University, Galway, Ireland, and graduated in the civil and mechanical engineering course at McGill University in 1877. He opened an office in Montreal in 1878 and built up a large and profitable practice as an engineer, architect and surveyor. The most notable undertaking accomplished by Mr. Walbank was that of organizing a company to develop the power of the Lachine Rapids of the St. Lawrence River a few miles west of Montreal. He organized the Lachine Rapids Hydraulic Land Co. in 1895, and soon after the stock of this company passed into the hands of the Montreal Light, Heat & Power Co. in 1903, he became Vice-President and Chief Engineer of the last-named company. A complete account of his career was published in Engineering News, April 4, 1907, p. 371.

Engineering Societies.

COMING MEETINGS.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 1. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

MONTANA SOCIETY OF ENGINEERS.
Jan. 6-8. Annual meeting at Butte, Mont. Secy., Clinton H. Moore, Butte, Mont.

MICHIGAN ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Lansing, Mich. Sec., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 13-15. Annual convention at Indianapolis, Ind. Secy., Chas. Brossmann, Union Trust Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 18-20. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting at New York City. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF INSPECTORS OF PLUMBING AND SANITARY ENGINEERS.
Jan. 20-22. Annual convention at Trenton, N. J. Secy., C. S. McCosker, Mobile, Ala.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 25-27. Annual meeting at Ottawa, Ont. Secy., C. H. McLeod, 413 Dorchester St. West, Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting at Cairo, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURER'S ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

INTERNATIONAL CONGRESS FOR MINING, METALLURGY, APPLIED MECHANICS AND PRACTICAL GEOLOGY.—The date for the 1910 meeting at Düsseldorf, Rhemish Prussia, has been definitely fixed as June 20-23.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—The title of the paper by Mr. Edward R. Taylor, to be presented at the annual meeting in Philadelphia, Dec. 8-10, has been changed to "A Method of Smelting Iron Ore in the Electric Furnace." The complete list of papers for this meeting was published in our issue of Nov. 18.

NEW JERSEY SANITARY ASSOCIATION.—Among the papers to be presented at the 34th annual meeting at Laurel-in-the-Pines, Lakewood, N. J., Dec. 3-4, are the following: "The Disinfection of Water and Sewage," Clyde Potts, New York City; "The Sewage Disposal Plants of New Jersey," Earle B. Phelps, Boston, Mass. Mr. E. W. Harrison, of Jersey City, N. J., will present a discussion of Mr. Phelps' paper and Mr. Geo. W. Fuller, of New York City will discuss the paper by Mr. Potts.

AMERICAN ECONOMIC ASSOCIATION.—A 25th anniversary celebration will be held in joint session with the American Historical Association at New York City, Dec. 27-31. The American Statistical Association, Secy., Carroll W. Doten, 491 Boylston St., Boston, Mass., and the American Association for Labor Legislation, Secy., John M. Andrews, Madison, Wis., will meet in New York City at the same time, holding joint sessions with the American Economic Association. The secretary of the American Economic Association is Mr. T. N. Carver, Harvard University, Cambridge, Mass.

NEW ENGLAND WATER WORKS ASSOCIATION.—The December meeting will be held at Hotel Brunswick, Boston, Mass., Dec. 8. The following program is announced: "The Underlying Principles Governing Riparian Water Rights and Diversion Suits," Chas. F. Choate, Jr., Boston, Mass.; report of committee appointed "to collect data relating to awards that have been made for damages resulting from the diversion of water, also to consider the practicability of joint action with the National Cotton Manufacturers' Association or other organization of mill owners, leading to the formulation of standard rules and methods of computing or assessing damages from the diversion of water," Chas. T. Main, Leonard Metcalf, S. A. Hale, Chas. E. Chandler, Wm. Wheeler; report of committee "to gather statics relating to the depth at which water pipes are laid and the resulting experience with frozen pipes," Frank A. Barbour, R. S. Lea, W. C. Hawley, R. Winthrop Pratt, Emil Kuichling, W. C. Hood, Dabney H. Maury.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.—The third annual meeting will be held at Ames, Iowa, Dec. 28 and 29. Among the papers to be presented are the following: (1) Land rollers, H. B. Bonebright (Colorado Agricultural College); (2) Plowing and tilling machinery, Frank D. Blake (Deere & Co.); (3) Standardization of farm machinery, A. O. Fox (Northern Electrical Co.); (4) Draft apparatus for the lecture room, C. M. Shedd (University of Nebraska); (5) Traction engines, W. F. McGregor (J. I. Case Threshing Co.); (6) Tilling with traction engines, E. W. Hamilton ("American Thresherman and Farmer"); (7) Disposal of farm sewage, Anson Marston (Iowa State College); (8) Flow and capacity of tile drains, E. W. Hamilton (Iowa State College); (9) Irrigation, J. T. Stewart (University of Minnesota); (10) A six-stroke cycle engine, M. L. King (Iowa State College); (11) Instruction in agricultural engineering, H. C. Ramsower (Ohio State University); (12) Making and selling farm implements, G. H. Ranney (International Harvester Co.) The Secretary of the Society is Prof. L. W. Chase, Professor of Farm Mechanics at the University of Wisconsin.